JOURNAL OF

THE INSTITUTE OF PETROLEUM

FOUNDED 1913 + INCORPORATED 1914

Vol. 36 JUNE 1950 No. 318

Contents

The Importance of the Preservation and Packaging of Equipment for the Oil Industry.
By D. A. S. Williams.

Interim Report of the Oxidation Panel of Standardization Sub-committee No. 6.

Determination of the Water Content of Motor Fuels.
By S. J. W. Pleeth.

Annual Report.

Thirty-seventh Annual General Meeting.

Grease.
By E. A. Evans.

Gas Lifting Oil in the Turner Valley Field.
By S. F. Shaw.

Obituary: George Thomson.

Abstracts.

Books Received.

Applications for Membership or Transfer.

Published by the Institute of Petroleum,
Address: Manson House, 26 Portland Place, London, W.1.
Telephone No.: LANgham 2250.
Telegraphic Address: Instpetech, Westdo, London.
Printed in Great Britain by Richard Clay and Company, Ltd., Bungay, Suffolk.

Price 10s. 0d. Annual Sub. £4 14s. 6d. (Post Free)

COUNCIL, 1950–1951

PRESIDENT:

C. A. P. Southwell, M.C., B.Sc.

PAST-PRESIDENTS:

Sir Andrew Agnew, C.B.E.
S. J. M. Auld, O.B.E., M.C., D.Sc.
J. S. S. Brame, C.B.E., F.R.I.C.
T. Dewhurst, A.R.C.S.
A. E. Dunstan, D.Sc., F.R.I.C.
E. A. Evans, M.I.Mech.E., F.R.I.C.
F. H. Garner, O.B.E., Ph.D., F.R.I.C.
J. Kewley, M.A., F.R.I.C.

VICE-PRESIDENTS:

M. A. L. Banks, B.Sc., F.R.I.C.
E. J. Dunstan, M.Sc.
F. Morton, Ph.D., F.R.I.C.
J. S. Parker, M.A., B.Sc.
H. C. Tett, B.Sc., D.I.C.

MEMBERS OF COUNCIL:

W. S. Ault, B.A.
V. Biske, LL.M., B.Sc., F.R.I.C.
C. D. Brewer, M.I.Mech.E.
E. B. Evans, Ph.D., M.Sc., F.R.I.C.
F. L. Garton, M.A., B.Sc.
H. S. Gibson, C.B.E., M.A., M.I.Mech.E.
J. G. Hancock
E. LeQ. Herbert, B.Sc.
H. Hyams
J. A. Oriel, C.B.E., M.C., M.A.
H. E. F. Pracy, B.A.
D. L. Samuel, B.Sc., A.R.I.C.
G. H. Smith, Ph.D.
R. B. Southall
E. J. Sturgess, B.Sc.
G. H. Thornley, M.Sc.
E. Thornton, B.Sc., F.R.I.C.
H. de Wilde, M.Sc., M.I.Mech.E.
A. T. Wilford, B.Sc., F.R.I.C.
C. S. Windebank

EX-OFFICIO:

I. McCallum, B.Sc. Fawley Branch.
N. E. F. Hitchcock, B.Sc. London Branch.
T. W. Ranson. Northern Branch.
W. M. Stirling, A.M.I.E.E., M.Inst.F. Scottish Branch.
E. J. Horley. South Wales Branch.
A. G. V. Berry, F.R.I.C. Stanlow Branch.

HONORARY SECRETARY: C. Chilvers, B.Sc., F.R.I.C.

HONORARY TREASURER: G. H. Coxon

HONORARY EDITOR: F. H. Garner, O.B.E., Ph.D., F.R.I.C.

HONORARY ASSOCIATE EDITOR: E. B. Evans, Ph.D., M.Sc., F.R.I.C.

EDITOR: George Sell

GENERAL SECRETARY: D. A. Hough, A.I.A.C.

TECHNICAL SECRETARY: Peter Kerr, M.A., B.Sc., F.R.I.C.

HON. SECRETARIES OF BRANCHES

Fawley Branch: I. McCallum, "Tresida," New Road, Hythe, Southampton.

London Branch: H. G. Spence, c/o Shell Petroleum Co. Ltd., St. Helen's Court, Great St. Helen's, London, E.C.3.

Northern Branch: G. M. Davies, c/o Anglo-American Oil Co., Mode Wheel Installations, Trafford Wharf Road, Manchester 17.

Scottish Branch: W. M. Stirling, Scottish Oils Ltd., Middleton Hall, Uphall, Broxburn, W. Lothian.

South Wales Branch: E. J. Horley, National Oil Refineries Ltd., Llandarcy, Glam.

Stanlow Branch: V. Biske, Lobitos Oilfields Ltd., The Refinery, Ellesmere Port, Cheshire.

Trinidad Branch: J. S. Collcott, B.Sc., c/o Trinidad Petroleum Development Co. Ltd., Palo Seco, via Siparia, Trinidad, B.W.I.

VOL. 36. NO. 318. JUNE 1950

THE INSTITUTE OF PETROLEUM.

AN Ordinary General Meeting of the Institute was held at Manson House, 26 Portland Place, London, W.1, on Wednesday, March 8, 1950, the President, Mr E. A. Evans, in the Chair.

The Minutes of the preceding Ordinary General Meeting held on February 8, 1950, were read, confirmed, and signed.

THE GENERAL SECRETARY (D. A. Hough) read the list of elections since the preceding meeting, and announced particulars of the meeting to be held on March 29.

THE PRESIDENT: This evening we have with us Mr D. A. S. Williams, manager of the Export Department of the Shell Petroleum Co. His particular province is to gather stores, equipment, and materials to be sent overseas to the company's fields and refineries and to be used even for building towns.

He has to provide a very wide range of materials, from hairpins to anchors—both of which I believe serve comparable purposes! I am sure that those who have had an opportunity to look through his paper on the preservation and packaging of equipment will agree that it comprises an enormous amount of very interesting material.

MR WILLIAMS then presented his paper, as follows:—

THE IMPORTANCE OF THE PRESERVATION AND PACKAGING OF EQUIPMENT FOR THE OIL INDUSTRY.

By D. A. S. WILLIAMS.*

SUMMARY.

The operations of oil companies depend on their materials and equipment being delivered to site in first class condition. Bad packaging accounts for a proportion of damage and loss. The commonest causes of this and the extent of the true loss are examined. An outline is given of a theory for determining the economic cost of packaging. The need for development of technique, of statistical data on which calculations can be based and for packaging to be treated scientifically are stressed; lines of approach to these problems are suggested.

"*Robert Louis Stevenson has told us that 'to travel hopefully is better than to arrive'. For the trader despatching his goods to markets near and far the reverse is true. All his work is null and void if his goods do not arrive at*

* Shell Petroleum Co. Ltd.

their destination, and arrive in as good a condition as when they were manufactured. Hope is no substitute for adequate packaging."

THESE words are quoted from the December, 1949, issue of the *Journal of the Anglo-Egyptian Chamber of Commerce*, and they strike straight to the core of the matter. They apply equally to all goods, for all destinations.

Oil companies have for long devoted a great deal of attention to the packaging of their own products. The very nature of the products has developed the necessity for this close study, and it is not intended that this paper should touch on it, although general principles which apply to packaging in general apply equally to this particular problem.

THE IMPORTANCE OF MATERIALS.

The packaging problems to be considered are those applicable to the very varied assortment of equipment, stores, and materials which the oil industry acquires for its own use. The fact that these stores and materials are subsidiary to the main business of the oil industry is apt to lead to their receiving less attention than they deserve. To win oil, equipment and materials are essential; without them oil cannot be won, refined, or distributed; much of the economic success of these operations is dependent on the efficiency with which the equipment serves its purpose.

Since the operations of the oil industry are principally overseas, the problem is one which has much in common with the general export trade of Britain. The broad requirements of the oil industry are in no way special. It wants material and equipment which will do the job for which it is purchased under the prevailing conditions at the site, and costing no more than the purchaser can afford to pay; the material should be delivered to the place where it is to be used in time to do the job for which it is required, and for this it needs to be in good, usable condition. That is exactly what all other customers want, so that manufacturers who are in a position to meet the requirements of the oil industry in these respects are undoubtedly working on lines which will benefit them in their entire business.

PACKAGING AS A FACTOR IN PRODUCTIVITY.

There is another line of approach to the problem. Great attention is focused nowadays on productivity, but at the same time there is a tendency to look at this mainly from the point of view of greater *production*. It is sometimes overlooked that there is no virtue in production of itself; goods are produced *for use*. The ultimate user is the one whose use of the goods justifies the effort and material consumed in their manufacture, and any failure to deliver the goods in a condition which will enable him to get the maximum use from them reduces not only his productivity, but the productivity of all who have hand in the manufacture and transportation of the goods themselves, as well as of those who contributed services to their manufacture, such as raw materials, power, tools, and so on.

Packaging of the goods is a vital function in this scheme. Whether expenditure on packaging is regarded as an insurance against loss of productivity, or whether it is regarded in the light of the possible annoyance of the recipient should he receive the goods in unusable condition—a very

proper and practical consideration, because it is on the opinion of the ultimate user of the goods that much of the manufacturer's prospect of further business depends—packaging must achieve a certain minimum level of performance for economic and practical efficiency.

Causes of Inefficient Packaging.

Experience has shown that in far too many cases this minimum level has not been reached. There are several reasons for this.

Manufacturers who turn out vast quantities of a limited range of products, like the oil companies themselves, usually give close attention to the packaging of their own products. It is susceptible to great standardization and can have a profound influence on the firm's production and marketing arrangements, but it is often the case that the firm's own production requirements and the need for sales appeal take pride of place in the design of the package, whilst consideration of the conditions the package will have to withstand after leaving the factory seem at times to have been almost overlooked. A typical example is that of rubber knee-boots, packed two dozen pairs in a carton, sealed with gummed-paper strip without wires or steel strapping, and with " Rubber boots " and the firm's name printed prominently on the outside of the carton. It is an easy and cheap package to use and has apparent good advertising value, but when stowed at the bottom of the hold these cartons squash flat or burst; when sent to a humid climate the gummed paper comes unstuck and the contents fall out; pilferage on the way to almost any destination is phenomenal, due to the clear advertisement of the nature of the contents, which are readily saleable on the black market.

Another cause of low-quality packaging is due to the fact that the cost of packaging is normally regarded as part of the first cost of the goods. Buyers often lack discrimination in assessing the importance of this component of the price they pay for the goods. Sales departments of manufacturers, in their anxiety to offer an attractive price, equally often tend to cut their packaging costs in order to remain competitive, little realizing that in so doing they may be throwing away the goodwill of the ultimate user. Professional packers complain that, against their better judgment, which is based on very close contact with the problems involved, they are often forced to pack down to the price which a customer is prepared to pay, knowing very well that it is based on an inadequate specification, instead of being allowed to provide a good and serviceable job at only a fractional increase in cost.

The cure for these difficulties is theoretically simple—buyers should always be thoroughly conscious of their responsibility for seeing that they safeguard their outlay on the goods by ensuring that the packaging is adequate, even if this means spending a little more money on it. Manufacturers' sales departments could, with advantage, take the initiative in specifying good packaging and selling the advantages of it to their customers. Unfortunately this solution is not simple in practice, since for it to apply generally it involves the education of tens of thousands of salesmen and buyers in the principles of packaging technique and economics. The oil companies, as a compact body of large buyers, and The Council

of British Manufacturers of Petroleum Equipment, however, should be in a good position to develop this.

A third cause of inefficient packaging applies particularly to engineering and similar products, which are seldom largely repetitive, and therefore involve a high proportion of purpose-made packages. The packing-shop is so often the cinderella of many factories dealing in this class of work. Frequently staffed with men who have had no opportunity of learning their job except from others equally unfortunate; with the foreman frequently occupied almost entirely with arrangements for despatch of the goods, so that he has little time for designing efficient packages and for seeing that they are properly made; and with little understanding by the works' management that the success of the whole works' output depends on the efficiency of the packing-shop, it is not to be wondered at that the results achieved are sometimes lamentable.

The Need for Education.

The cure for this can be only a long-term one; it is outstandingly important, and is a matter in which the Institute of Packaging could take a leading part. The provision of suitable training courses in trade schools at which packing-shop personnel can learn their trades on correct principles would go far to counteract the system whereby a workman, who has already developed some undesirable methods in doing his work, can teach them to a learner, who in turn, after adding a few more bad methods of his own, can pass them all on to another.

Technical colleges could, with advantage, introduce the subject as part of their regular training schemes in commercial and technical subjects to ensure that all who have contact with materials in any form are made aware of the importance of the subject and its underlying principles and are taught that the ultimate satisfactory usage of material is the sole objective in the whole chain of commercial and manufacturing processes. Yet other courses should be available at technical colleges for those who wish to specialize in the subject, so as to ensure that their practical work is built on a sound theoretical basis.

Once all this is set in train, and time has allowed the results of the teaching to take ffeect, it is to be expected that status of the packaging department will be substantially improved. It will be called in to advise the production, technical, and sales departments as to the effect of packaging on their problems, in exactly the same way that the foundry, not so very long ago regarded as being " in but scarcely of " an engineering works, now gives very valuable advice and assistance to other departments, based on a good combination of sound theory and practice.

In the meantime it remains a never-failing source of wonder that so many firms should invest so much money and brains in striving after the ultimate in every branch of design, production, inspection, testing, and sales promotion, but who, nevertheless, if the attention they devote to packaging their products is any guide, appear to take little interest in them after they leave the factory gate. Such firms—and there are many of them—if unwilling to go to the extra trouble of developing their own packaging technique, would be well advised to put themselves for this work into the hands of a first-class packaging contractor, taking his advice,

and at the same time feeding him with all the information possible on out-turns, so that by co-operation they will obtain results which will be to the advantage of both.

Oil companies can do much to help themselves and others by asking for their suppliers to quote a price for the goods delivered f.o.b., with a separate price and specification for the packaging. This gives an opportunity to evaluate the packaging proposed at its true worth, and to introduce any modifications which experience may show to be necessary without holding up the progress of the main order. It also makes it easier to evaluate the economic level of expenditure on packaging.

The Economic Level of Packaging.

This evaluation of what is an economic price to pay is not easy, since the problem is influenced by many factors. An example to illustrate the underlying theory is given in Table I. In this example the calculations

Table I.

Effect of Varying Package Cost.

Cost of article	100	100	100	100	100	100	100	100	100	100
Cost of packaging	0	2	4	6	8	10	12	14	16	18
Packed cost	100	102	104	106	108	110	112	114	116	118
Freight and insurance say	10	10	10	10	10	10	10	10	10	10
Landed cost	110	112	114	116	118	120	122	124	126	128
Duty (say 15%)	16·5	16·8	17·1	17·4	17·7	18·0	18·3	18·6	18·9	19·2
Duty paid cost	126·5	128·8	131·1	133·4	135·7	138·0	140·3	142·6	144·9	147·2
Local store and delivery, say	10	10	10	10	10	10	10	10	10	10
Delivered cost	136·5	138·8	141·1	143·4	145·7	148·0	150·3	152·6	154·9	157·2
Expectable loss :—										
% of consignments	100	61·71	31·73	13·36	4·55	1·24	0·27	0·05	0·01	neg.
Value of goods lost	136·5	85·6	44·7	18·1	6·6	1·8	0·4	0·1	neg.	neg.
If payback on goods is four years, productivity is 25% of cost p.a. If delivery time for replacement is six months, loss of productivity is 12½% of cost.										
Loss to user :—										
Loss of productivity, 12½%	17·1	7·7	3·6	2·3	0·8	0·2	0·1	neg.	neg.	neg.
Cost of packaging	0	2	4	6	8	10	12	14	16	18
User's outlay	17·1	9·7	7·6	8·3	8·8	10·2	12·1	14·0	16·0	18·0
Loss to country :—										
Loss of productivity	17·1	7·7	3·6	2·3	0·8	0·2	0·1	neg.	neg.	neg.
Replacement of goods	136·5	85·6	44·7	18·1	6·6	1·8	0·4	0·1	neg.	neg.
Cost of packaging	0	2	4	6	8	10	12	14	16	18
Country's outlay	153·6	95·3	52·3	26·4	15·4	12·0	12·5	14·1	16·0	18·0

are made for varying amounts spent on packaging in relation to the cost of the goods. Arbitrary but typical amounts have been chosen for ocean freight, customs duty, and local charges for storage and delivery to the site where the goods will be used.

It is borne out in practice that, up to a point, the more money is intelligently spent on packaging, the smaller is the proportion of goods which one may expect to lose. The increase in cost of packaging is by no means proportional to the reduction in risk. For the example under consideration figures for expectable loss have been taken which might apply to a material which would show 100 per cent loss if sent loose, but which can be adequately protected at comparatively low cost. This

relationship between the percentage of loss from consignments and the cost of packaging, assumed for this example, is shown in Fig. 1, but it is emphasized that these figures, although based on experience, are quite hypothetical, and are chosen merely to illustrate the example. Insufficient data are available for the production of such a precise curve on any one commodity.

The actual value of the loss is a function not only of the proportion of the goods which will be lost, but also of the delivered cost of the goods and

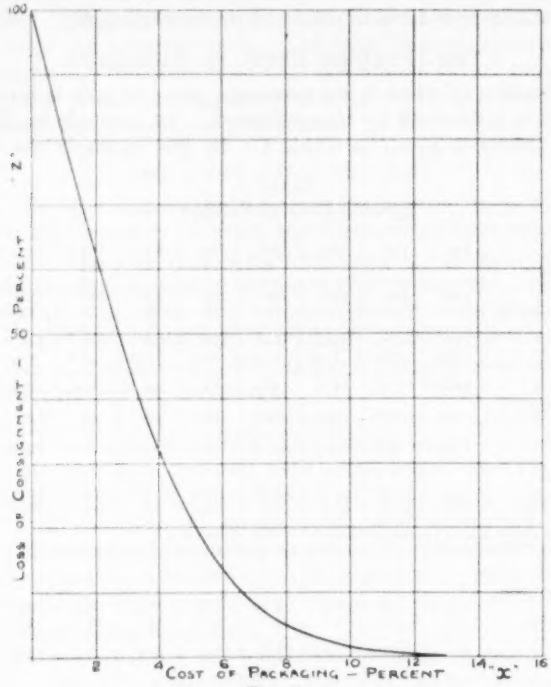


FIG. 1.

of their productivity. The company buying the goods to use expects a return on its investment in the form of its own production. In the past it was not unusual in the oil industry for materials and equipment used on producing plants to show a pay-back of their initial cost in two years; the productivity of the goods would in that case be 50 per cent of their landed cost per annum. If at the same time it should take, say, six months to replace the goods at site, the direct effect on the user of loss or breakage would be a loss of production during half a year, equal to 25 per cent of the delivered cost of the goods. He can measure the effectiveness of his packaging in terms of his total loss, which is the sum of the direct cost of packaging and the value of the loss of productivity it causes. Fig. 2 shows this in the lower curve as "loss to the user"; it will be seen that it reaches a mininum, for the particular conditions chosen for the example, when packaging costs are about 5 per cent of the value of the goods.

It is, however, wise in these days, when the welfare of all of us depends on industry achieving a maximum of useful production, to take a wider view and to study the effect on the country as a whole. The loss to the oil industry is the loss of productivity of the goods, and, as this refers to the British oil industry, it is equally a loss to the nation; on top of this, however, is the waste of the original effort which went into the manufacture and delivery of the goods, equal to their delivered cost. The user should therefore measure how effectively his packaging safeguards the national interest in terms of the cost of the packaging plus the loss of productivity it causes, plus the value of the goods lost. In Fig. 2 this is shown by the

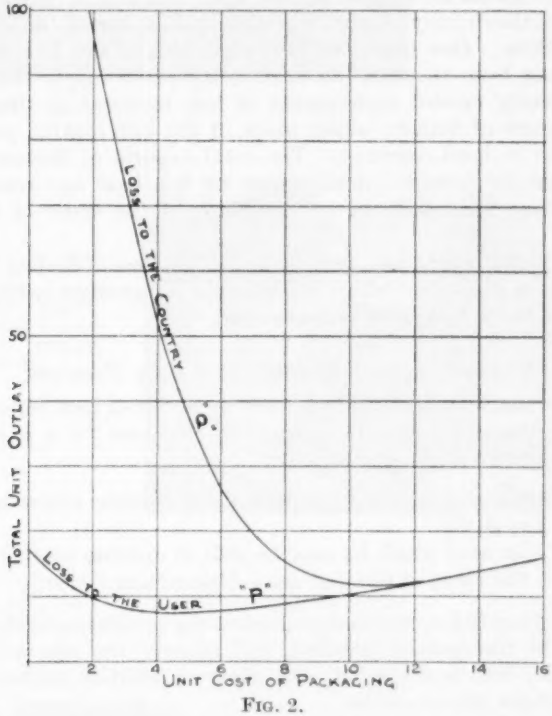


FIG. 2.

upper curve " loss to the nation," which in this example reaches a minimum when packaging costs about 10 per cent of the value of the goods.

In both these curves it is noticeable that, if packaging costs are cut, the overall outlay on packaging plus loss increases very rapidly indeed, whereas a greater outlay on packaging increases the overall cost quite slowly. It is clearly better therefore to err on the side of packing too well rather than not well enough.

In this example also, it can be seen that although packaging to keep the loss to the country at a minimum involves an overall outlay about 1·8 per cent greater than is needed to keep user's outlay at a minimum, the result of so doing reduces the loss to the country to less than a quarter of what it is at minimum loss to the user. In face of this, there is surely

every reason to take the broad view and to aim at a standard of packaging which will keep the loss to the country at a minimum, particularly since this also reduces interruptions and difficulties in operation caused by materials not arriving in usable condition.

The financial implications are important. The oil industry in Britain is buying materials and equipment at the rate of about £60 million per annum. This represents a "delivered at site" value of the order of £100 million per annum. It is difficult to estimate what proportion of goods are lost due to bad packaging, but it is believed to be about 1·5 to 1·75 per cent. Based on average delivery times for replacement and the approximate estimated overall pay-back on this expenditure, this represents a loss to the country of about £2 million per annum on the oil industries' shipments alone. One must not lose sight also of the fact that, due to delivery times from the U.K. so often being much longer than from the U.S.A., urgently needed replacement of lost material at times calls for the expenditure of dollars, whilst much of the lost earning power of the goods is also in hard currency. The total exports of Britain are about £1800 million per annum; if the losses on this bear any relationship to the above they must amount to something of the order of £30 million per annum.

A tentative mathematical approach to the problem of finding the level of expenditure on packaging which will produce the greatest overall economy is developed in an Appendix to this paper.

Factors Affecting the Choice of Package.

There are many variables which have to be taken into consideration in determining the most suitable package specification for a particular job. These fall into two main groups:—

(*a*) Those produced by conditions not directly controllable by the user of the goods.

(*b*) Those over which he may be able to exercise control, or at least in which the views of the user are a determining factor.

In the first group fall such circumstances as the conditions under which the goods will be transported, handled, and stored; the climatic conditions to which they will be subjected; the effect of different methods of assessment of customs import duties.

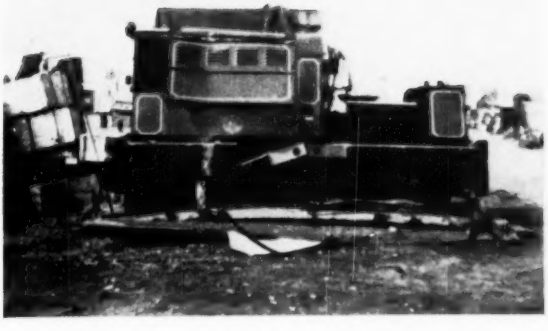
In the second group are included factors such as the intrinsic delicacy and liability to breakage of the goods; their intrinsic value; their attraction to pilferers; the urgency of need for them; and the seriousness to the user of possible loss or damage.

Development under War Conditions.

During the war the effect of these factors was closely studied by the Services, and as a result the technique of packaging military stores was developed to a very high level. It was, however, a relatively easy problem, because the very fact that they were military stores justified packaging to meet extreme conditions, and eliminated some of the factors which complicate the commercial approach to the problem.

ROAD CONDITIONS CAN LEAD TO SEVERE SHAKING UP OF TRUCK LOADS.

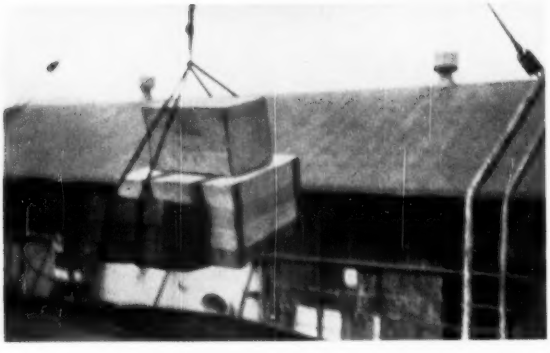
THERE IS NOT ALWAYS ROOM TO STACK GOODS TIDILY ON PUBLIC WHARVES.



EVEN VERY ROBUST MACHINERY CAN SUFFER SEVERE DAMAGE IF THE CASES ARE NOT STRONG ENOUGH.

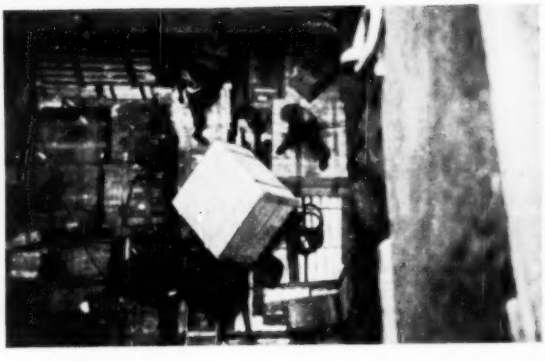
[*To face p.* 316.

WEAKNESS OF THE DRUM HAS LED TO TOTAL LOSS OF THE WIRE ROPE — THE RISK OF KINKS RENDERS IT UNSAFE.



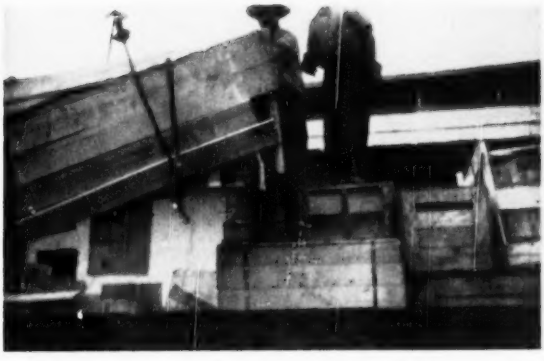
NORMAL SLINGING IMPOSES DISTORTING AND CRUSHING STRESSES ON THE PACKAGE.

THE TOPS AND CORNERS OF CASES MAY HAVE TO WITHSTAND HEAVY LOCAL LOADING.

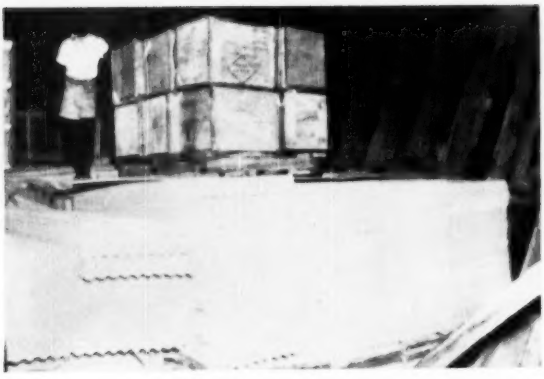


CASES ARE SOMETIMES LAID ON THEIR SIDES ON UNEVEN SUPPORT.

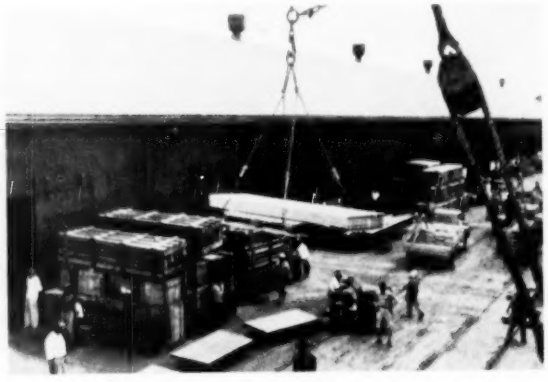
LONG BENDABLE ITEMS LIKE SUCKER RODS AND PIPE CALL FOR ADEQUATE SUPPORT AND CAREFUL PROTECTION OF THE ENDS.



EVEN THE MINIMUM OF STEEL STRAPPING CAN HOLD A BROKEN CASE AND ITS CONTENTS TOGETHER.



LOW-COST FRAGILE MATERIALS LIKE ASBESTOS SHEETS CAN SHOW A GOOD OUTTURN IF CAREFULLY STOWED AND HANDLED WITH PROPER GEAR. NOTICE THE ERROR MADE IN BREAKING OUT THE CASED GOODS BEFORE THE MORE FRAGILE CARGO HAS BEEN DISCHARGED.



For war purposes it was safe to assume that transport conditions would be at their worst, that the goods would be handled by inexperienced labour, and that they would often be stored in open dumps. Perfect out-turn was required under extreme climatic conditions, such as in tropical New Guinea, in the mud and rain of Normandy, and in the Arctic. Customs regulations did not intrude.

There was a relatively short list of about 600 common types of military stores, and their liability to damage could be easily determined even if it was not already well known. Value was not assessed in terms of money, but by need; the need for the stores might be very great in the prosecution of a campaign, and the risk if they failed to arrive in good condition was the possible loss of the war.

To meet these extreme conditions three basic types of package were evolved which were highly effective. Unfortunately they are quite uneconomic for the bulk of commercial requirements.

The Commercial Problem.

Contrast the variety of commercial conditions with those affecting war stores. Transport in the main is reasonable, but for some destinations, particularly when subject to much transhipment, it can be as severe as anything met in wartime; the capacity of dockside labour to break goods varies considerably—some ports are good, others terrible; storage conditions can vary from excellent warehouses under the supervision of highly competent staff down to outdoor dumps, which in difficult circumstances may not even be covered with tarpaulins. The oil industry in particular operates in all climates from the Arctic to the most severely tropical, but it is unfortunate that oil seems to be found largely in districts where heat, humidity, insects, or fungoid growth, and usually combinations of these, create major problems.

The method of imposing import duties varies from place to place. When charged *ad valorem*, attention should be concentrated on obtaining a perfect out-turn of the goods; when charged on gross weight, the weight of the package becomes of extreme importance. This is particularly the case with fragile goods, such as electric-light bulbs, which at the same time are fairly expensive, but weigh little, so that they carry a high duty per kilogram. It is not unusual for the package to weigh as much as or more than the bulbs, and it calls for nice judgment in the design of the package to keep the customs duty down without excessively raising the loss due to breakage.

There is a huge variety of goods to be considered, varying from articles very sensitive to heat and moisture, such as photographic film and some pharmaceutical preparations, to frail laboratory apparatus, large radio valves, and delicate instruments. The problem varies from packing a tube of toothpaste so that it does not get squashed or lost, to trying to fix heavy machinery so that it can be carried in aircraft.

The stake varies just as much, from a routine replenishment of stores whose loss would scarcely be noticed, to emergency requirements of the most extreme nature on which the safety and potential production of a whole oilfield might depend.

For commercial reasons the bulk of goods has to be packed to a specification designed to meet an average combination of these circumstances. Quite often this average is set too low, due to a lack of appreciation of what really are the conditions which the package will have to withstand; many manufacturers and packers would do well to look into this, but there is no commercial advantage to them in catering in their general run of packaging specifications for more severe conditions than those they can expect the general bulk of their production to have to meet. The actual average conditions to cater for depend on what the manufacturer makes; the average conditions for special oilfield equipment are different from those for a universal commodity like food. It may at times be worth running two or three different grades of package for the same goods.

It is, however, important that these average conditions for which normal packages are designed should be recognized as such. Should any of the circumstances applying to a particular consignment be appreciably more stringent than the average, the probability of loss will be sharply increased. Experience has shown that it is well worth while studying all consignments, and selecting those which will have to withstand more than average conditions and to give these special packaging treatment designed to meet the particular circumstances.

It is customary for the oil industry to buy its stores and material "delivered f.o.b. packed for ocean shipment," or on some similar terms. The onus is therefore basically on the manufacturer to pack his goods so that they will arrive in good shape. It is asking a good deal of any manufacturer that he should know for himself all the varying circumstances which may apply to each consignment of his goods, and oil companies can do a lot to help themselves and the manufacturers by putting their knowledge of these things at the disposal of their suppliers. Nevertheless, it is impossible to escape the need for manufacturers to become self-sufficient in this knowledge as soon as they can, because they cannot expect as much assistance from the generality of overseas customers in providing this information as the oil companies are willing to extend to them.

The B.S. Packaging Code.

The British Standard Packaging Code, produced by the British Standards Institution with remarkable speed during the war, served as a guide to the packaging of Government supplies. Although, as has already been said, some of the detailed specifications of packaging methods in it are not commercially attractive, a close study of it is strongly recommended to those who have not already done so, because the underlying principles of good packaging which it sets out apply universally. The Code is being re-published sectionally as the present revision of it proceeds. It is a great step in the right direction; nevertheless, it does seem almost certain that as experience is gained in its application to commercial packaging it will require still further revision.

The Code suffers from two deficiencies—they cannot be called defects, since they both fall outside its original conception. The first of these is that, although it gives excellent advice on how to do it if the reader knows what he wants to do, it does not lend itself at all readily to helping a buyer

who knows what sort of packaging he wants in conveying this information to a packer who does not know. It can be done, but only in a very cumbersome manner; in order to simplify this an attempt is being made to classify the more commonly used methods of packaging so that a relatively simple classification code will convey all the information required and will enable the recipient to find in the Packaging Code itself the full detail of what is expected of him.

The second deficiency is that a reader, faced with the problem of packaging a particular job, can get little guidance from it as to which of the many possible solutions it offers is the best. It may not be the proper function of the code to do this, but whether or not this is so, there is great scope for the development in some authoritative text-book of precise guidance as to the best type of package to use under any given circumstances.

Need for Statistical Background.

To measure the effect of different methods of packaging requires the accumulation of a statistical background of results which at present seems to be almost completely lacking; without it no scientific approach is possible; present methods, which are based on the practical experience of those concerned, can at best give only "hit or miss" results. The gathering of statistical information of this nature is not easy, because on account of the variety of conditions a very large number of results are required to give a workable picture. A first and necessary step is agreement as to the information to be collected; thereafter the co-operation of a small number of companies shipping relatively large quantities of a wide variety of material to many destinations should in the course of two or three years give sufficient data to make a start on its interpretation. Co-ordination of work of this nature would be a valuable help to the study of the whole subject of packaging, and it is suggested that if the Institute of Packaging could undertake this and the oil industry could co-operate in collecting the data a great step forward would be made.

Packaging a Link in the Economic Chain.

Up to this point the economic aspect has been dealt with in its simplest form, regarding only the immediate effect of a loss, but on top of this, packaging is one of many functions linked in an economic chain. For example, someone makes an article and earns wages in doing so; the article is sold to the oil industry, is packed and shipped to its destination, where it is used to win oil. The oil is shipped to Britain, where it can be used in an omnibus to take the man to work to make another article, as well as being used to run the ship which carries the article, and to lubricate the machines on which it is made. If the packaging fails in its function of delivering the article in good usable condition, a link in the chain is broken. To some degree the oil is not won, and for lack of oil the ship cannot sail, the machines cannot run, and the man cannot get to the factory to make the replacement, which the oil industry now urgently needs because its customer, the bus owner, is complaining because he is short of fuel. The breaking of one economic chain breaks others which are interconnected with it; the repercussions are endless, and the whole tendency is towards

a general slowing down of industry and a lowering of the standard of life. Packaging is not an unimportant side-issue.

Insurance of goods in transit is no answer to the problem; the best it can do is to spread the loss over a wider portion of the community after the damage is done. Nothing can replace the wasted effort. The objective must be both to avoid the waste of the initial effort and to safeguard the productivity of the goods. The productivity of the goods lies in their use; the productivity of a package is measured by the productivity of the goods packed in it expressed in terms of the cost of the package.

Experience of the Last Four Years.

A survey made by the author's company of its own consignments some four years ago showed that the two principal causes of complaint about packaging at that time were breakage of outer containers and damage due to water and humidity. It had been the practice up till then to accept without query, whatever package a supplier offered.

The actual extent of the damage caused, and its disruptive effect, both in the company's own operations overseas and on the reputation of British goods, was deemed to be so serious that an intensive campaign was started to have outer containers strengthened and more scientifically constructed. Representations have been made to the Timber Control on many occasions to remove restrictions which are a common cause of the use of inadequate scantlings; much detailed instruction has been given in the more scientific use of bracing, handling aids, and in the general design of packages, but in far too many instances this has had to extend also to such elementary things as how to nail timber together so that it will not come apart.

Considerable attention has had to be given to the packaging of small heavy articles like nuts and bolts, small valves, nails, and similar goods which are usually shipped in small bulk packages; the contents of these act under shock as very heavy fluids, or as solids with a very small angle of repose, and the containers need, therefore, to be designed to resist bursting stresses in excess of those met with in drums of liquid. Boxes and cases, however strongly made, are fundamentally unsuited to this type of load.

Waterproofing.

Experience has shown that simple waterproofing of packages with bitumen-paper, if properly carried out, saves much damage not only from rainwater or spray, but also to a limited extent, and rather surprisingly, from humidity in the atmosphere. A great deal of the effort applied in this direction has, however, been wasted by careless sealing of the edges of the bitumen-paper, by the use of an inferior quality, by driving nails through it, leaving it in contact with unpadded sharp edges, and even by inadequate protection from external damage. In this, as in most aspects of packaging, the ship is easily spoilt for a ha'p'orth of tar; failure to carry out one part of the packaging process properly only too often nullifies the effect of the whole of the correctly done remainder.

Internal Support.

It is pleasant to record that complaints of broken packages and water damage now form a very small proportion of the total, although complaints about inadequate packaging still occur in 35 per cent of the total complaints received about materials supplied. Breakages of material, particularly engineering equipment, inside undamaged outer containers now form the major portion of the complaints, and considerably greater attention will obviously have to be devoted to this aspect than has been done in the past. Cushioning of brittle material (of which cast iron is one of the most troublesome); support of overhanging heavy parts of machines; support for relatively heavy machines mounted on light stands, which are quite adequate for their purpose once the machine is installed, but which are quite unable to withstand shock loads; chocking of goods inside the package so that they are equally secure whether the case is right side up or upside down; all need attention.

Pilferage.

Pilferage is still a serious problem. Casual loss from this cause is fairly easy to deal with by strict avoidance of any indication on the outside of package of the nature of its contents and by seeing that the contents do stay inside the package. In some instances the camouflaging of attractive parts to render them less conspicuous is worth while. The usefulness of chromium-plated instrument bezels as picture-frames, and the popularity of stainless-steel fittings as ornaments in some quarters, led to a regular practice of painting these over with an easily removed bitumen paint before shipment to render them less conspicuous. This form of casual pilferage is, however, not thought to be as serious as the work of well-organized gangs. The skill with which goods can be extracted from cases, then weight made up with bricks and the case left with no obvious defect is quite astonishing. There are various thief-proof devices which can be used with advantage in the manufacture of cases, but the best all-round method of dealing with this problem seems to be strapping securely with high-tensile steel tension-strapping, laid on both ways at close intervals as tightly as possible. Hoop iron nailed on, and tension strapping made of soft steel laid on loosely or at wide intervals can sometimes serve a useful purpose by keeping the contents inside a broken case, but it is useless as a safeguard against organized pilferage.

Marking.

Marking of packages offers scope for much study. It is not sufficient only at long last to be able to match a consignment with its appropriate documents. Marks should give an immediate indication of the origin and local destination of the consignment, particularly when several consignments of similar material are shipped together, so as to facilitate correct stacking when the ship is discharged; otherwise much local expenditure can be incurred in sorting out the goods on the wharf before they can be delivered. This applies particularly to bundles of structural steelwork, tank material, and similar consignments which are difficult to identify

apart at sight. Not only should the bundles be clearly marked (and they can with advantage be far more securely strapped than is normally the case), but every individual piece in the bundle should be marked, so that in the event of bundles coming adrift, as is apt to happen, the individual pieces can be quickly sorted into their appropriate heaps and rebundled correctly.

It is a great help if proper itemized contents' lists are attached to the outside of cases where they can be readily found and examined without having to open the case should the case marks be rubbed out; these lists need to be protected from damage by a metal plate and must be sealed in envelopes of waterproof material, such as cellophane, if they are to remain readable. Similar protection needs to be given to instruction books, spare-parts lists, and similar documents enclosed in a case with the goods, otherwise they frequently arrive in so mildewed a condition that they are useless.

Protection against Corrosion.

The B.S. Packaging Code deals very fully with the principles of protecting metal parts against corrosion: these principles have been found to apply almost in their entirety to commercial packaging, but recent technical developments in corrosion preventives have opened up new detailed methods of application.

Some difficulty has been experienced in ensuring that the application is correctly done. It is frequently overlooked that a soft corrosion preventive such as may be used on highly finished machine parts itself needs protection if the protective film is not to be damaged; thoroughness of application is too often lacking; soft films are often used where hard varnishes would be more appropriate and vice versa; evidence of ineffective cleaning before preservation often appears in the form of finger-prints corroded into metal surfaces.

It is also very regrettable that some engineering firms still seem to be content to treat their products with a coat of so-called "slush," laid with a brush on to the parts which are easy to get at and omitting those which are awkward, and apparently without having given much thought to whether the "slush" itself has any corrosion preventive value at all. Cases have also been met where the protection has been exceptionally difficult to remove without damaging the part it was supposed to protect.

Bearing in mind the large amount of research work which has been necessary in order to develop corrosion preventives which really do their job and are easy to remove afterwards, and for the development of a proper technique in their application, this attitude appears to be very short-sighted. It is to be hoped that the oil industry, which has taken a leading part in the research into and development of some of these products, will at least show an example to others in their use.

Pliable plastic films are exceptionally useful for some purposes, particularly for intricate and highly finished spare parts which may have to remain in storage for an indefinite period, because they seem able to ensure a perfect out-turn of their contents without any maintenance expenditure whatever. They are sometimes more expensive in first cost than the more

usual methods, but when it is borne in mind that spare parts, when wanted, are usually wanted urgently, their use for this purpose is often fully justified.

There is also a wide field of application for the newer vapour-phase inhibitors, the possibilities of which have not yet been fully explored. These offer two particular advantages. In the first place they are easier of application than some of the other methods, requiring fewer processes to achieve an equal degree of protection; to the extent that they are easier to apply, they are the more likely to be applied properly. In the second place, by delivering the article in a bright, clean, ready-for-use condition, they save the user the often troublesome and messy job of cleaning it before he can use it. They also offer considerable opportunities for storing small items in the manufacturer's original container with the certain knowledge that they will not corrode; this helps to keep stores' bins tidy, and again saves in stores' maintenance costs. For it to be successful, however, manufacturers need to devote considerable attention to producing stronger types of carton and to proper marking to show exactly what is in them, otherwise the storekeeper prefers to keep the items in the open where he can see them.

Conclusion.

In the author's experience, the importance of good packaging to industries, such as the oil industry, which are large users of materials and equipment is not always realized; the subject is in many cases dealt with on a rule-of-thumb basis, and he wishes to make grateful acknowledgment to the management of the Shell Petroleum Company and to his colleagues for their encouragement towards trying to deal with it in a scientific manner.

The function of packaging forms such a vital link in the whole process of supply of material, without which the industry cannot operate, that although more limited, it requires as precise thought and execution as does the function of engineering. It is impossible in a paper of this nature to do more than point out some of the underlying principles and to outline the present stage of development, but it is hoped that this may help to arouse interest in a subject which deserves all it can get.

APPENDIX.

A tentative mathematical approach to the problem of determining the economic level of package cost for a given set of circumstances is given below. It has not been possible to develop this fully, due to lack of data with which to establish certain necessary relationships. As and when such data becomes available, the method is capable of development to give a rapid solution to the problem.

Symbols.

L	Cost of goods per gross ton.
x	Cost of packaging as a fraction of cost of goods.
K	Cost of ocean freight and insurance per gross ton.
y	Rate of import duty as fraction of landed cost per gross ton.
C	Cost of local transportation and storage at destination per gross ton.
Z	Proportion of loss from consignment expected for quality of packaging costing x.
a	Payback period of goods—years.
b	Average replacement time of goods—months.
M	Value of expectable loss—per cent of L.
P	Loss to user—per cent of L.
Q	Loss to country—per cent of L.

Development.

Cost of goods	$= L$
Cost of packed goods	$= L(1 + x)$
Landed cost	$= L(1 + x) + K$
Cost, duty paid	$= [L(1 + x) + K](1 + y)$
Delivered cost	$= [L(1 + x) + K](1 + y) + C$
Value of expectable loss	$= Z([L(1 + x) + K](1 + y) + C) = M$

Annual earning power of lost goods $= M/a$.
Loss of earnings whilst awaiting replacement $= Mb/12a$

Loss to user $= (Mb/12a) + x$
Loss to country $= [M(1 + b)/12a] + x$

or, in full,

Loss to user $= Zb/12a\,([L(1 + x) + K]\,(1 + y) + C) + x = P$
Loss to country $= Z(1 + b/12a)([L(1 + x) + K](1 + y) + C) + x = Q$

These losses will be a minimum when dP/dx and dQ/dx respectively equal 0.

In order to solve these equations, and thereby to ascertain the value of x which will give minimum cost, it is necessary to express Z, the expectable proportion of loss, in

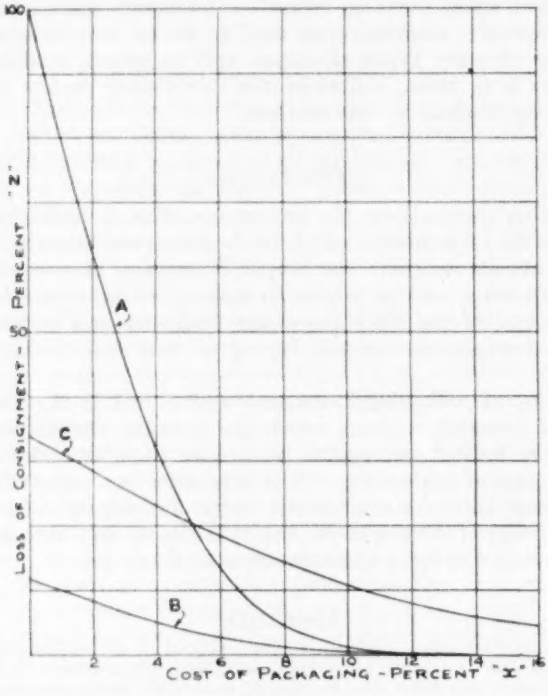


FIG. 3.

terms of x. This will vary for each type of goods and, broadly, for different types of destination. A large volume of practical data is required to establish an empirical relationship.

In general, the relationship can be represented by curves of the general types A, B, and C in Fig. 3. Curve A is that used in the example in Table I: it shows a probability of 100 per cent breakage for material shipped unpacked and a moderately rapid fall in probability as cost of package increases, with reasonable practical protection at a package cost of 10 per cent.

Curve B would apply to a commodity showing a low probable loss at zero packaging, and this probability rapidly becoming negligible at a moderate packaging cost around

10 per cent. Curve *C*, which might apply to certain types of machinery, shows a moderate loss at zero packaging, but a relatively slow diminution of loss as package cost increases; really effective protection would only be obtained at around 25 per cent package cost.

Although no attempt has been made to determine the mathematics of these curves, it is felt that there is a likelihood of their all being of one general family, possibly of the form

$$Z = 100 - (A + f(x)).$$

It would be useful if the mathematics of the curves could be established at an early date. If in the event it were found that they are of the same family, empirical determinations of the constants for particular classes of goods would be greatly speeded up, since it would be necessary to determine only two points on the curve for each. Until the mathematical nature of the relationship is known, there is no alternative to the laborious process of obtaining a sufficient number of results on each commodity/destination group to develop an approximation for that group.

Discussion.

The President: We are fortunate this evening in having with us Mr Ashwell, the President of the Institute of Packaging. We offer him a very warm welcome, and I would ask if he would care to open the discussion. Recently he has been to America, and if he can tell us something of the impressions he gained there, it will be extraordinarily interesting.

Mr G. M. Ashwell: I should like first to express my thanks for the invitation extended to me as president of our newest technical Institution. I have had the privilege of listening to Mr Williams before, and as always he makes things so clear that it is difficult to find questions to put to him.

He made mention of pilferage, and obviously as an export nation we are very concerned with this subject. I have just returned from the U.S., having led a team under the Anglo-American Council on Productivity, and although we were mainly concerned with retail packs, we were naturally to some extent concerned with packages for overseas shipment.

By comparison with ourselves the U.S. is not an exporting nation to anything like the same extent: they have a very live home market, and the export side is quite secondary to home sales. Nevertheless, packages containing goods which are likely to prove a temptation to a thief, passing through the port of New York do, almost without exception, give no indication of the contents.

With regard to damage, there is a great tendency for the consumer not to say how he wants the goods packed, and for the shipper or manufacturer to pack as cheaply as possible. When damage arises the customer will be compensated through insurance: surely this is wasteful, both as to materials and goodwill?

Whilst in New York I had the privilege of attending a meeting of the Maritime Association of the Port of New York, which body consists of some 1500 members comprising insurance companies, shipping companies, shippers, and others who use the port. These members recently set up a committee consisting of three representatives from insurance, shippers, and shipping companies to consider means of improving packaging and handling to deal with general problems concerning merchandise through the port of New York. I felt that this was a great step forward in co-operative effort which might well be followed elsewhere.

Mr Williams mentioned the question of education: my Institute has given consideration to this, and we hope as a trial run in the early Autumn of the present year to hold a week's course in packaging in London. It is proposed to hold an examination at the end of the course, and we look forward to the assistance of experts in packaging in imparting their knowledge.

I agree wholeheartedly with Mr Williams's remarks relating to expenditure on packaging: I feel that any company spending, say, £50,000 a year on packaging would be well advised to have a man on its staff who devotes the whole of his attention to packaging, and would be responsible both from the technical and economical aspects.

DR D. CLAYTON: I agree fully with all the author's comments.

On the point that manufacturers meeting the requirements of the oil industry will be meeting those of other users, it is important that users should not ask individually for special methods and materials; they should be able to leave manufacturers to choose a standard that will be adequate for all and yet economical in application, by having discussions on a sufficiently wide scale. It is very true, as the author says, that many firms, having put extremely good work into the production of their units, appear to take little interest in them after despatch. In odd cases it has been found that the manufacturers are indeed shocked when they see their product in store or being fitted after storage. I understand that manufacturers of petroleum equipment have been taken to see, not only the job it has to do, but also the conditions under which it is used; it will do a tremendous lot of good for manufacturers to see what happens to their products, even in Britain. Many manufacturers do not even take ordinary precautions, however. For example, I have seen gear pinions of 5 in or so diameter, with well-finished teeth, and even sides, but streaked with rust from rain due to absence of corrosion preventive and packaging; again, ground bar is in many cases delivered without corrosion preventive, and rusts in storage so that it has no advantage over black bar.

As regards the influence of packaging considerations on design and production, I have known cases during the war where this was evident. For example, the clutch unit of vehicles should have been further broken down for delivery because of difficulty in arranging for rust prevention. Also it is clear that during assembly much good can be done in corrosion prevention by using corrosion-inhibited oil instead of ordinary lubricating oil, and adopting the regular practice of putting a dab of grease on all threads before putting on the nuts. Castings should be kept free from rust throughout their early life if there is not to be trouble from rusting; in weathering, the porous places and sometimes the graphite pits get moisture in them, and this leads to re-growth of rust under paint films, however well the top layer of rust is removed by scratch brushing.

I have found a number of cases in which, due to limitation on capital expenditure, corrosion prevention by the manufacturer is being questioned; this is a problem that might call for investigation, though the extra charge is small.

I agree with the author on both the need for statistical evidence and the difficulty of getting it. For the engineering stores used in Britain, it is

rare for them to be unusable, and therefore the assessment will have to be in terms of workshop and fitters' time in re-conditioning them after rusting or mechanical damage.

The reference to breakage within packages suggested that support should be given to the work of the Printing, Packaging, and Allied Trades Research Association, which is investigating such matters, and should be able to derive fairly readily information on the relative durabilities of different packages and different designs of machines from this point of view.

I would direct attention in connexion with corrosion prevention to the revision of Section 3 of the Packaging Code (B.S. 1133) which is nearing completion. An attempt is being made to set a minimum standard of performance for the various corrosion preventives, and tests for the various accessary properties are being put forward. As regards thoroughness of application, I have been surprised to see a fairly large delivery of electric motors in which only the top half of each projecting shaft had been coated with protective! Removability has certainly been a problem; it is emphasized in the new version of the Packaging Code that all materials must be removable with common petroleum solvents, even after ageing.

I agree that vapour-phase inhibitor has a number of very attractive features, but feel on the evidence I have that more information is needed by users to give them confidence in applying it correctly and to show the circumstances in which it will behave satisfactorily.

With regard to the adequate marking of containers in order to avoid storekeepers opening them, emphasis must be laid on the trouble that arises with such articles as ball bearings, due to their wrappings being torn off instead of the identification marks being read; consequent losses from corrosion are serious, and, moreover, there is considerable danger from the bearings getting dirt in them.

I know from experience how difficult it is to get these ideas over to manufacturers and others, and that the author will have to be very persistent.

Dr A. H. Nissan: The practice of balancing cost of packaging against losses in transport is an old one. I was reading recently that the early slave traders were faced with that problem. They were shipping slaves from Africa to the Southern U.S., and if they packed too many into a ship, too many of them died, so that they arrived at their destination with less slaves than would have been the case if they had embarked fewer to begin with. They made calculations, and decided on a loss margin of 20 per cent.

Apparently, although the problem is so very ancient, the lesson has not yet sunk completely into the minds of some modern exporters and manufacturers.

Some ideas seem to die very hard indeed. Consider, for example, the strength of packaging. Recently we were discussing the merits of fibreboard packaging *versus* kegs for certain materials. The matter was serious, because the shipping companies were opposed to fibre, whereas they passed wooden kegs as being all right. The problem at issue was that of strength, and some drop tests were called for. Wood is obviously stronger than fibre as a material, but not necessarily so as a whole container when dropped

on a corner. Several kegs were filled with the same weight of contents and dropped as specified. The wooden kegs were very strong, but very elastic, and as they were dropped the two ends just flew out : only about one-third of them survived the first two drops. The fibre board, not being elastic, but more plastic, flattened when it was dropped, but it would withstand thirty-six drops. That illustrates the point that a material may be stronger than another when tested as a material, whereas in the final packaging, the weaker material can be the stronger, because a package is a structure, and a structure depends not only on the strength of its members, but also on their shape and relative dispositions.

With regard to V.P.I. corrosion inhibitors, how do they behave when applied to non-ferrous materials ? Do they give a measure of protection to those materials, or are they used specifically for ferrous materials ?

E. C. Masterson : In the first place, I would like to comment on the reference made by the speaker to the care which must be exercised by manufacturers in packing their goods. Speaking as a user of equipment and not as a manufacturer, I think it is only fair to state that we must also do our part in seeing that packages are properly handled when received at their destination. This is a most important point, more especially when opening up oilfields in new areas where proper handling facilities are not available. I refer to jetties, cranes, experienced crews, and so forth. I know of one field in the Middle East where there were no adequate facilities available during the early stages of development. Ships had first to be unloaded on to barges ; the goods were subsequently transferred on to a temporary jetty ; then conveyed by lorry over very bad roads for distances of 20 to 30 miles. Great quantities of material were brought in during these early stages when no facilities were available ; and under these conditions a great deal of damage occurs, no matter what the packaging is like.

One of the most important factors in this connexion is that it is essential to train handling crews immediately operations start ; otherwise goods are mishandled, with consequent damage.

The speaker made no particular reference to the handling of " fragile " items. These goods arrive in countries like the Middle East in packages bearing the work " fragile " in English, or bearing a reproduction of a wine glass to indicate which way up the package should be kept. An Arab is supposed to know that the position marking, as represented by the wine glass, indicates that the parcel should be held a certain way up. In fact, he does not, and I am of the opinion that some more effective method of marking is required—one easily recognized in all parts of the world.

In any part of the world a red light on a road indicates a " stop " sign, and wherever one may be driving one knows that if one comes to a red light, one will have to stop. Again, fire engines all over the world are painted red, and if one hears a ringing bell and sees a red vehicle driving along the road, one knows that it is a fire engine, long before it gets near one. If, on the other hand, a vehicle sounding a bell is approaching and this vehicle is painted white, one is pretty sure it is an ambulance. Developing this idea, would it not be possible to adopt a standard method of painting fragile boxes, in order to distinguish them easily from ordinary

non-fragile packages. If, for instance, it was generally accepted that the top of fragile boxes should be painted, say, black (in order to get over the colour-blind problem), then stevedores and porters, or anybody having to handle such a box, would know at a glance that it contained a fragile article. As an additional precaution, I suggest that the black paint be continued on to the sides of the box for a distance of about one foot, so that a fragile case may easily be spotted, even if someone had put another box on the top of it, thus covering up the black paint. If such an idea were generally accepted and standardized, damage to fragile materials should be very considerably reduced.

G. Vivian Davies : I should like to query the reference in the paper to quoting a price for goods delivered f.o.b. Does not the author mean "ex works," because that seems to me to be a most interesting suggestion, particularly for a manufacturer who is making very heavy equipment which might cost up to £20,000? If he is to allow even 5 per cent as cost of packaging, that means an expenditure of £1000, which is quite considerable in an increasingly competitive market. Thus if he could sell his goods ex works, just as the motor-car manufacturer sells his cars ex works, he could leave it to the customer to decide how good the packaging has to be. That means throwing the onus on the purchaser, of deciding how much should be spent on this.

Another point which has been mentioned is that the packagings in which goods are sent overseas are not returnable, though they have a considerable residual value. In one place in the East I found quite a good structure had been built out of old cases for use as a stores, the subdivisions of which were also formed of empty boxes.

I had something to do with tank parts from the U.S. during the early part of the war, and I have never in my life seen worse packaging. I think, however, that the Americans improved matters very quickly, because the aircraft parts which were sent to us later in the war were packed extraordinarily well.

In the early days a certain film company sent representatives to the Near East to take a film; but they omitted to cover their films in lead. Most of them became quite useless and the shots had to be re-taken.

An interesting problem arose in regard to some pump equipment for which I was responsible. It was found that the sandblasting had not been properly done, with the result that when the oil-tanks were painted afterwards with anti-corrosive paint this flaked off and got into the oil circuit, as the result of which the equipment was almost wrecked.

Finally, I wonder why the makers and users of heavy equipment have not thought of putting rollers or wheels under the cases in which this is packed. I am quite sure that such provision would enable those cases to be moved about very much more easily at the docks and other places than they are at present.

D. A. Hough : I should like to amplify the remarks of the last speaker with regard to containers. I do not know whether any one here has ever been in command of war vehicles in the middle of an arid desert when a line of tanks is approaching, and you are far from certain as to which

side they were on? Especially as you could be fairly certain that most of the vehicles under your command had no petrol left at all. This question of petrol packaging became far from an academic problem on such occasions. The fuel was supplied in monstrosities known as 4-gal tins, apparently made of the softest known material. They bounced about on the trucks to their complete detriment, particularly the corners. Often several tins would be received which contained no petrol at all, and often the cap would be rusted in so that it became necessary to cut round it.

Again, most of the vehicle petrol tanks held about 18 gal, so that if a tank were empty to start with one had 2 gal over by the time it was filled. The remaining 2 gal were, more often than not, thrown into the sand of the desert, and I cannot imagine how many millions of gallons of petrol must have been wasted in that manner.

The Germans used the jerry can, which was excellent, and it is amazing how near this simple difference between their method of packing and ours came to costing us the war in North Africa in the early days of the desert campaign.

E. THORNTON : I want to make a suggestion about a packaging test which I am sure will come. My mind goes back about forty-five years to my first contact with this problem. The chairman of a firm of instrument-makers was concerned because the firm's range-finders, were continually returned, when they were sent out on approval, as having been damaged in transit. He was a brilliant physicist, as well as a humourist, and he solved the problem by means of a mechanical British porter, a mechanical combination of cams and shock-producing devices. His claim was that if a package could survive the mauling given by this machine, it could defy the worst any railway handling could give it. He finally sold the range-finder to the Japanese, and claimed that they beat the Russians because of it!

It would be useful to have some such device which will indicate how good a package is, without having to send it across the world and back again, and no doubt something like this exists.

E. C. TICKLE : I would like to take up the question of drums and jerry cans.

These are two fundamentally different types of drum. First there is the 5-gal drum, a one-trip job entirely; that drum is never returned by the user, for it does not pay for reconditioning. Then we jump to the jerry can, which, apart from any other question, is much more difficult to produce and is much more expensive; it was never designed for oil, but for spirit.

We went into the last war almost without any idea of how we were going to pack any liquids at all. If you knew of some of the early trials to put oil into 26-gauge drums for transport overseas, to put spirit into 4-gal tins or ordinary 40-gal or 45-gal double-seam drums, you would, with me, take off your hats to those who travelled across the seas with those drums in the holds of their ships, for the drums were not designed for that purpose.

Therefore, I emphasize that there is a big field for the consideration of the packaging of the products of the oil industry.

S. L. WITARD : I note that Mr Williams has not referred to sand; and anybody who has been out in the fields realizes what can happen in the event of a sandstorm occurring. A few months ago I had five days of it. We had some pumps in packing-cases, and in the course of the sandstorm a good deal of sand got through the cases and through the inspection covers, which were slightly open. If only a few grains of sand get into the bearings, you can say " good-bye " to those bearings.

As to the suggestion that certain colours might be used to distinguish the contents of packing-cases, I would remind you that some of the companies indicate destinations by colours. For example, the stevedores know that blue means Basra and red means Abadan. Thus, we need to be very careful about the selection of colours used to distinguish types of articles.

G. L. ASHWELL : I believe that 15 per cent of the population of the world are colour-blind; and I believe the standard code of colours has outlived its usefulness, because none of us know where we are with these things.

As to the use of symbols to indicate whether the contents of packages are fragile, explosive, corrosive, and so on, I believe that in some places livestock, for instance, is indicated by a cockerel, or a representation of a cockerel, a ventilator by a fan, and an instruction to keep away from the boilers is indicated by a stove. Such simple symbols, such as might be used in the nursery, might be useful in some of the ports of the world—or even in ports of Britain.

H. D. HEMMINGS : The quality of the wood used in packages is an important factor. As an illustration of difficulties which may arise, we had a case made for export, and it stood in our works for five or six weeks, by which time the wood had shrunk so much that we had to take off the strapping. One is led to wonder whether such a case would be of any use at all after a long journey of five, six, seven, or eight weeks duration, and what might be the condition of its contents on arrival at final destination.

MR WILLIAMS, replying to the discussion, said : Many points have been raised and it would be very difficult, though interesting, to deal with them comprehensively.

It is said by Mr Ashwell that the consumer does not usually say how he wants his goods packed and that the suppliers therefore tend to pack as cheaply as possible; if damage occurs the user comforts himself with the thought that his insurance company will pay for it. Unfortunately many suppliers also tend to adopt a similar attitude when taxed with the inadequacy of their packaging.

Insurance is, however, no answer to the problem. It should cater only for extraordinary circumstances—things which are not at all likely to happen. It can operate only after the damage is done, and cannot recover the wasted effort. We are concerned with productivity, which is measured in terms of effort, not finance.

Consumers do not say how they want their goods packed because they usually know little about packaging, and so do not know really what they want. To a large extent the manufacturers' packers do not know the conditions the goods will have to meet after they leave the works. I think the broad position is that many people know that something is wrong and want to do something about it, but are uncertain what to do. The answer is to get together and exchange information; the sum total of the knowledge possessed by many people is bound to exceed that of any one of them. If they can collaborate in accumulating a reasonable fund of knowledge, they can then spread it about and see that it is passed on correctly. The New York Maritime Association have given us a good lead in this, and the move made by The Institute of Packaging towards providing education in the subject deserves a full measure of support.

There is a good deal of information to be had about conditions overseas, but it takes a lot of digging out, and is often rather vague. In my opinion, nothing can take the place of a personal investigation. However familiar a circumstance may be on paper, it often looks very different when you see it with your own eyes, and in many cases cannot be fully understood by any other means. Special journeys of investigation overseas may be expensive, but their cost can be saved many times over if the lessons they teach are well learnt.

Dr Nissan mentioned a good example, when quoting the slave trade, of the advantage of studying the job at first hand. In those days the slave-trader collected the slaves himself, was captain of his own ship, and had direct contact with the user; he was therefore in a good position to calculate precisely what to do. Another case comes to mind; one of my own staff went for a long trip in a truck carrying stores and equipment to one of our fields. He could not sit down for a couple of days afterwards, and that led him to wonder how the goods felt about it!

It is interesting to hear that Dr Clayton even feels that these personal visits by manufacturers should start at home. There can surely be no excuse for not following up that suggestion, but I think that any wide-spread success in getting manufacturers to adopt, as a routine, adequate steps to prevent corrosion at all stages of manufacture is unlikely until they are in far closer contact with what their customers actually do with the material they buy.

On the question of the highest common factor of customers' needs, the normal basis for packaging must be to meet the normal conditions which the goods are likely to encounter. That level varies according to the nature of the goods. In the case of specialized oilfield equipment, which will go nowhere but to an oilfield, where conditions are nearly always primitive and severe, I do not think it can be too well packed. In the case of a common-user item, such as food, which may go anywhere, the normal conditions are probably much less severe, and a lower level of protection will suffice. If you can size up the level of conditions which a particular consignment would normally be packed to meet and if the actual conditions applying to that consignment are worse than this, even in only one respect, then it pays the user handsomely to tell his supplier that he will have to raise the standard of his packaging for that particular consignment. One abnormal circumstance alone may be enough to make

the whole package fail. After all, one hole can sink a ship; the same principle applies to packaging.

It is in any case a waste of time carrying corrosion prevention of major items of equipment to a very high degree—for example, hermetically sealing and dessicating the package—unless all the users' stores personnel, as well as customs' officers, stevedores, and others who have to deal with it are first fully trained to deal with it correctly.

Dr Clayton mentioned the high cost of repair and refurbishing due to corrosion and breakage; I think these costs are seldom collected—they are usually lost in "general overheads." I think it would pay firms using large quantities of materials to keep these costs separately—they might find them surprisingly large. Another aspect which must not be lost sight of is that material lying idle for this cause represents so much extra capital locked up in unnecessarily large stocks, and may often cost a very large sum in loss of production due to the material not being available when wanted.

Dr Nissan's case for the fibre carton, which squashes, as against the keg, which bursts, is well made, but it is, of course, dependent on the contents being able to withstand squashing without hurt. If the contents have to be kept in shape, then they would in fact be protecting the package and not the other way round.

Vapour-phase corrosion inhibitors are just as effective in protecting non-ferrous metals from atmospheric corrosion as they are on ferrous metals.

I agree completely with all that Mr Masterson says about the importance of setting up proper handling facilities in freshly opened-up areas. We have had cases where the workshop equipment, sent out for the repair of such damage as may occur, is itself damaged and therefore unrepairable on site. This can lead to much unforeseen expenditure.

I am certain that users, particularly the oil industry, must differentiate between the various areas to which they ship goods. For a new area it is necessary to package almost up to war-time military standards. In some established areas the transport conditions are also frightful. For one oilfield in South America there are fourteen or sixteen trans-shipments before the goods arrive at their destination, and in bad weather the land journey may take six or eight weeks. At every trans-shipment there is a potential of loss and breakage. Incidentally, one thing we have learnt is never to load cases of fragile goods into a tipping truck—the temptation to save effort on unloading is too great.

I can offer no very useful suggestions on how to deal with fragile and similar items. It is an extraordinarily difficult problem, because we are up against the fantastic variations of human reaction; these cannot be standardized, and I do not think we want them to be.

No system of marking can be perfect; some people are colour-blind; an Arab does not recognize a wine glass. An Arab does know all about cockerels, but if we paint a stove on something meaning "Keep away from boilers," and he happens to know what a stove is, he is just as likely to light a fire under it to keep it warm.

I can quote a good example of this sort of thing. I have seen on a wharf in South America cases having wine glasses painted on them, yet they were upside down, on end, and in fact, in any position. When I

commented on this, I was told that "any fool knows that you can turn an empty glass upside down." The suggestion was quite seriously made that it might be worthwhile painting an empty glass on the case with a piece of hinged tin to represent the wine. This would fall out of the glass, and it was thought that the local people would notice this and go to the trouble of righting the case and putting the wine back into the glass. It raised my opinion of the local stevedore's capacity for logical thought, but logical thought does not apparently always lead where one would expect.

We do use colours to a certain extent, mainly for identifying mixed lots of goods, such as structural steel work, which cannot be recognized at a glance. For instance, you can put a splash of red paint on all parts for one building, green for another, and so on; so that they can be sorted out quickly by not very intelligent labour.

I believe the solution can only lie in treating these special markings as conventional signs, chosen for their convenience rather than any pictorial suggestion they may convey, and to concentrate on teaching the convention to all concerned. It may take many, many years, but in the end the bulk of them will play the game according to the convention. After all, arithmetic is nothing but a convention, yet most people can do it, though it is hard work teaching some of them.

On the question of testing, raised by Mr Thornton, I believe the Packaging, Printing and Allied Trades Research Association has a host of mechanical porters, horses, stevedores, bottle washers, and all sorts of similar things and has done a tremendous lot to devise methods of testing packages. Such things help. A mechanical method of testing enables one to measure the value of the result; but first you have to know what value of result is required in order to achieve your object. In this respect you have to bear in mind the essential difference between a mechanical British Railway Porter, for instance, who will always do the same thing, and a real railway porter, who does not.

In reply to Mr Vivian Davies' query on my suggestion that manufacturers should quote a price "f.o.b. British Port, packaging extra," I do mean f.o.b. Our practice is to ask for a price for the goods delivered on board ship; we ask also for a separate price for the supplier's normal export package and for particulars of what he proposes. If we think something better is required, we develop a suitable packaging scheme with him and pay the extra. If anybody is prepared to accept delivery "ex works," plus cost of packaging, this would serve the same purpose of separating the cost of the package from the cost of the goods, though it may create difficulties in other directions if applied universally—for example, with Purchase Tax.

The second-hand value of packages can sometimes be an important consideration. In some areas they are almost the sole source of softwood timber, and are valuable as such. The 4-gal petrol tin is, of course, an outstanding example of this, being used for everything from cooking-pots to house building.

I do not think there is now much difference in standards of packaging as between Britain and the U.S.; both are very good at times, and both are extraordinarily bad at other times. The U.S. have one great advantage in an ample supply of good indigenous timber.

The provision of wheels or rollers on heavy cases would be sound but for the fact that there is often nothing hard to roll them on. Skids and lifting irons are better. If you provide something handy, such as a nice ring into which to put a hook, a man is more likely to put the hook into the ring. If you do not, he may put the sling on anywhere and drop the case as a result, or may simply bowl it over and over to save fetching the crane.

I am glad reference was made to the damage which can be caused by sand getting into moving parts, if only for the reason that the inspection covers of some pumps were left open.

One of the first rules of packaging is to close and seal all openings, because trouble can equally arise from spray or rain-water getting in. We have had water into the unblanked exhaust manifolds of oil-engines, which rusted up the valves, pistons, and liners and let us in for a lot of replacements before we could use the engines.

There was another case of a man who tried to do the job well; he removed the instruments from some electric switchgear for better packaging separately, as they were delicate. He blanked off the holes in the switch housing with steel sheet blanks, but left out one $\frac{3}{16}$-in screw. When the switchgear was installed, it was fortunately noticed that this tiny hole had been used as an entry by a variety of bug which had built several nests between the busbars, which would have short circuited the apparatus.

As to the quality of timber available in Britain, much of it is wet as it comes from the timber yards, and if cases are made from it in this state they do shrink and the steel strapping does fall off. The cure is simple; buy dry timber if you can get it, but if you cannot, then carry a sufficient stock so that it has time to dry in your own yard before use.

I am very grateful to you for the interest you have shown and for the large number of points you have made in this discussion.

THE PRESIDENT: This is the first occasion on which we have had the subject of packaging brought to the notice of the Institute of Petroleum and, from the discussion we have had, it has revealed the widening field of interest of the Institute. I have been extremely fascinated because, naturally, I do not think so much about packaging as do some of you; when I saw Mr Williams' curves and formulæ it seemed to me that we had got down to something really basic. He has given us much to think about. He has given us a paper carrying a message, and it is my privilege to thank him for a very delightful paper.

In doing so I would emphasize a comment he made on vapour-phase inhibitors, when presenting his paper. He suggested that possibly many of us did not know enough about them. I think that so far there is only one company which is marketing one. So we cannot altogether be blamed. Vapour-phase materials are worth thinking about; they have a future. I know something about them, for we have done a certain amount of work on them in my laboratory, and I can verify that they are worth considering in connexion with packaging.

On behalf of the Institute of Petroleum, I thank you very much indeed, Mr Williams, for your most delightful paper, which has created great interest.

(The vote of thanks was warmly accorded, and the meeting closed.)

INTERIM REPORT OF THE OXIDATION PANEL OF STANDARDIZATION SUB-COMMITTEE NO. 6.

Members of the Panel:

R. D. Streeton (*Chairman*)

S. C. Atkinson	J. Mason
D. Clayton	A. C. Pepper
J. C. Cragg	T. M. Taylor
P. W. L. Gossling	H. L. West
D. H. Japes	E. H. Wild
R. L. Martin	D. Wyllie
L. O. Maskell	

Object.

To standardize an oxidation/corrosion test within the framework laid down by the Technical Committee of the Lubricating Oil Pool.

The test was required to differentiate between straight mineral oils and H.D. engine oils approved to U.S. Navy Specification 14–0–13 or U.S. Army Specification 2–104B. The need being urgent, it was subsequently agreed that as an interim measure, differentiation could be considered on the basis of corrosion only, though work on oxidation and hydrolysis should proceed.

Conclusions.

Sunbury Test.

On the restricted basis given, using a test piece of pure lead as stirrer, the modified Sunbury beaker corrosion test gives the differentiation required. The basis of measurement is the cumulative loss in weight of the test pieces over two successive 6-hr periods at a temperature of 140° C, catalysts and test pieces being changed at 2-hourly intervals.

Although reproducibility is not good, a clear distinction is obtained between the two types of oil. It is suggested that a limit of 50 mg lead loss provides a suitable datum line. Reproducibility is not improved by cleaning the test pieces by the chemical method adopted for the modified Indiana oxidation corrosion test.

The properties of the oxidized oil were such that it was not possible to differentiate clearly.

The modified Sunbury beaker test described in this paper differs in detail from the test described in the paper by F. W. H. Matthews on "The beaker corrosion test for lubricating oils" (this *Journal*, 1949, **35**, 436), notably in the temperature at which the test is carried out, and the metal which is corroded.

Indiana Test.

Results so far obtained with the modified Indiana oxidation/corrosion test indicate that the differentiation required between straight mineral oils

and H.D. engine oils approved to U.S. Navy Specification 14–0–13 or U.S. Army Specification 2–104B may be possible both on the basis of corrosion measured by the cumulative loss in weight of test pieces of pure lead during a 12-hr test, and by the determination of some characteristics of the oxidized oil after an 18-hr period of test, the test pieces and catalysts being changed at 3-hourly intervals.

Although reproducibility is not satisfactory, a distinction is obtained between the two types of oil in individual laboratories. It is possible that as a result of further work a better reproducibility might be obtained, but the decision must be made as to the justification for this further work, as the only advantage visualized over the modified Sunbury beaker corrosion test is the possible distinction on oxidation characteristics.

Appendices.

The report of the Joint Oxidation/Corrosion Panel of the Lubricating Oil Pool Technical Committee is detailed in Appendix I.

The development of the test methods is discussed in Appendix II.

Details of the modified Sunbury beaker corrosion test are given in Appendix III.

Some results obtained by the co-operating laboratories when testing the reference oils by the method described in Appendix III are given in Appendix IV.

The development of and the test procedure employed in the modified Indiana oxidation/corrosion test are discussed in Appendix V.

APPENDIX I.

Report of the Joint Oxidation/Corrosion Panel of the Lubricating Oil Pool Technical Committee.

Members of the Panel.

J. C. Cragg
P. W. L. Gossling
G. Kinner
L. O. Maskell
A. C. Pepper
R. D. Streeton
D. Wyllie
R. S. Teale (*Chairman*)

Terms of Reference.

To put forward to the Main Committee recommendations for a type of laboratory oxidation and corrosion test for H.D. oils in sufficient detail to enable the Oxidation Panel of the Institute of Petroleum to frame an appropriate test method.

Taking into consideration the directives laid down in the Minutes of the 236th meeting of the Pool Technical Committee, the Panel recommended that the I.P. Panel be asked to frame a test within the following framework.

Object of Test.

The formulation of a test for H.D. diesel engine oil combining measurements of oxidation stability and corrosiveness towards lead. Preferably the test should be developed so that oxidation and corrosion proceed simultaneously.

Duration of Test.

It should be possible to carry through the test completely in not more than a week.

General Outline.

It is recommended that the resistance to oxidation and the corrosive properties of the oil should be determined by exposure to a high temperature (in the neighbourhood of 170° C) without water, followed by exposure to a lower temperature (below

100° C) in the presence of water. The purpose of the second part of the test is to provide for the possible corrosive effect resulting from hydrolysis of additives, which may occur in practice. Pure lead should be totally immersed in the oil throughout the whole period, for the purpose of estimating corrosion.

Special Conditions.

Lacquer.—The effect of lacquer formation upon the degree of corrosion should be reduced as far as possible. This might be achieved by using a fresh test piece at regular intervals. An alternative of inserting the test piece only towards the end of the oxidation period has been considered, but it is felt that false conclusions might be reached in this way because at some intermediate stage in the oxidation the oil might be more corrosive than towards the end of the test.

Condition of Oxidation.—It is recommended that mechanical stirring should be used and that preferably no air current should be employed. If an air current is found desirable in order to secure a measurable degree of oxidation in a reasonable time it is recommended that it should be passed over the surface of the oil and not through it.

Volatile Products.—Volatile products should be partially retained by covering the container in which the oxidation is carried out, ventilation or access of air in conformity with the previous paragraph being provided by vents in the cover.

Catalyst.—It is recommended that a pure metallic catalyst be used, such as copper or copper plus iron. This might well be arranged so as to form part of the stirrer. The catalyst should be in the same physical condition for each test.

Evaluation of Oxidation.—The evaluation of the oxidized oil might be considered on the basis of the measurement of

(*a*) Increase in viscosity.
(*b*) Total insolubles in I.P. spirit and/or other suitable precipitant.
(*c*) Neutralization value.
(*d*) Saponification value.

These tests should be carried out on the oil at the end of the high-temperature oxidation period.

Evaluation of Corrosion.—Evaluation of corrosion to be determined by measuring the total change in weight of the test piece or pieces at the end of the test.

Additional Recommendation.—The effect of topping-up oxidized oil with new oil might be explored by adding an equal volume of fresh oil to a sample of the oxidized oil, and centrifuging or filtering with the object of ascertaining whether and to what extent precipitation appears.

APPENDIX II.

Development of Test Methods.

After careful consideration of the Report of the Joint Oxidation/Corrosion Panel of the Lubricating Oil Pool Technical Committee, the Panel decided to concentrate on the modified Indiana stirring test * and the Sunbury beaker corrosion test, with a view to developing from these methods a satisfactory test method which would differentiate approved H.D. engine oils from other oils on the basis of their corrosive effect on pure lead and, if possible, at the same time enable their oxidation characteristics and resistance to hydrolysis to be assessed.

The Panel was provided, by the Lubricating Oil Pool, with samples of four approved H.D. engine oils (Reference Oils Nos. 1–4) and one straight mineral S.A.E. 30 oil (R.O. No. 5) as being used by Sub-Committee No. 5 for engine tests. In addition, two other straight mineral oils (R.O. Nos. 6 and 7) were circulated, as it was considered that one oil only in this category was insufficient. Latterly, two other oils (R.O. Nos. 8 and 9) were circulated, R.O. No. 8 being a good pass, and R.O. No. 9 being a bare pass on the Chevrolet test.

On the advice of the Lead Technical Bureau, Chemical Lead Type A to B.S.S. 334 was selected as the most suitable grade to use for the estimation of the corrosive effect. The preparation of the surface of the lead has been the subject of much discussion and experiment, and it is felt that a method better than the one suggested is required. Advice from the British Non-Ferrous Metals Research Association has been obtained recently, but the techniques suggested have not yet been fully investigated.

Modified Sunbury Beaker Corrosion Test.

Preliminary work was carried out at various temperatures using a test piece of pure lead as stirrer, the test pieces and catalysts being changed at agreed intervals and the

* *Industr. Engng Chem. Anal.*, 1941, **13**, 317–21.

test being continued for varied periods. Some difference in the corrosive effect was obtained when comparing the straight mineral oils with the approved H.D. oils, but differences in the other oxidation characteristics were not pronounced. Experiments were conducted at 160° C, and 150° C, and finally at 140° C. At the latter temperature it was found possible to get a clear-cut distinction between the two types of oil on the basis of corrosion after two 6-hr period on successive days, if the test pieces and catalysts were changed every 2 hr. Throughout, no useful information was obtained on the basis of increases in viscosity, saponification value, or acidity of the oils. Attempts made to increase the oxidation of the oils by conducting the test without the beaker covers in position did not lead to any more satisfactory result.

Considerable attention has been paid to the standardization of test conditions, and it is felt that these are now controlled as closely as is practicable, with the possible exception of the initial preparation of the test pieces.

Modified Indiana Test.

The development of this method has not proceeded as far as for the Sunbury method, owing to the difficulty of obtaining the necessary apparatus.

Preliminary work, carried out at 160° C, indicated that a good distinction could be obtained between the two types of oil on the basis of their corrosive effect. Examination of the oxidized oils gives rise to the hope that a distinction, on the basis of tests carried out on the oil after oxidation, may be possible. Work has proceeded on the standardization of the apparatus; this has included re-designing the stirrer, and the fixing of the test pieces and catalysts. Insufficient tests have been carried out with the apparatus in its present state of development to come to any definite conclusion, and so it cannot be put forward.

APPENDIX III.

Modified Sunbury Beaker Corrosion Test.

Introduction.

The purpose of this test is to obtain a measure of the corrosive effects of an oil when in contact with a test piece of pure lead under conditions of temperature and turbulence.

The method comprises stirring a measured quantity of the oil at 140° C with a test piece of pure lead in the form of a paddle in the presence of a copper catalyst.

Corrosion is assessed by determining the cumulative loss in weight of the lead test pieces.

Apparatus (Fig. 1).

This shall consist of a Pyrex glass beaker, with an aluminium cover (Fig. 2) and a stirrer consisting of a pure lead test piece (Fig. 3). A heating bath shall be provided for maintaining the oil in the beakers at 140° ± 1° C.

(a) *Beakers.*—1500-ml capacity, tall form, with square lip to support the aluminium covers (see Fig. 1).

(b) *Thermometers.*—Low Distillation (I.P. 5W) shall be used for both heating bath and beakers.

(c) *Beaker Covers.*—These shall be of aluminium with apertures to accommodate the thermometer, stirring shaft, and copper catalyst. The cover shall have slides over the stirrer-shaft aperture to facilitate removal of the test piece (Fig. 2).

(d) *Heating Bath.*—This shall be such as to allow the immersion of the beakers to a depth of approximately 3 in in the heating medium. Details of a suitable bath holding four beakers are as follows :—

Dimension of oil bath.—10 in × 23 in × 5 in deep.

Stirring.—Two paddle stirrers situated 6½ in from each end of the bath. Diameter of paddles 2 in. Speed of rotation 900 r.p.m.

Lagging.—Glass wool covered with tin-plate.

Source of Heat.—2 × 300-W windings supported on porcelain insulators. The windings are arranged vertically, one along each of the longer sides of the bath. One element is coupled direct to the supply line, and the other is automatically controlled by means of a Sun-Vic thermostat (Type T.S.I.).

The top of the bath is fitted with a well-fitting, lagged cover provided with holes for accommodating the beakers, the shafts of the paddle stirrers, the current leads, and the bath thermometers.

(e) *Test Specimen Shafts.*—¼-in steel rods 12-in long, fitted at the top with a pulley and at the bottom with a test-piece holder as in Fig. 3.

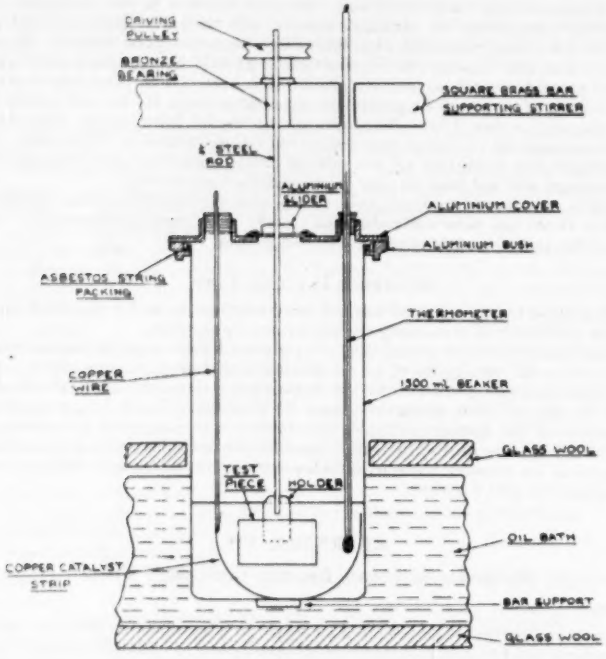


FIG. 1.

GENERAL TESTING ASSEMBLY.

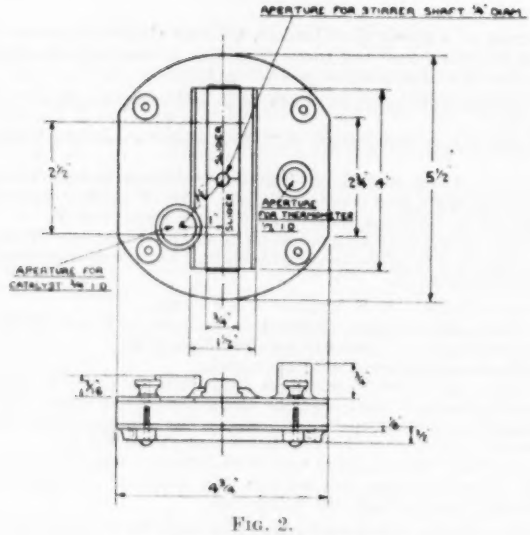


FIG. 2.

ALUMINIUM COVER FOR BEAKER.

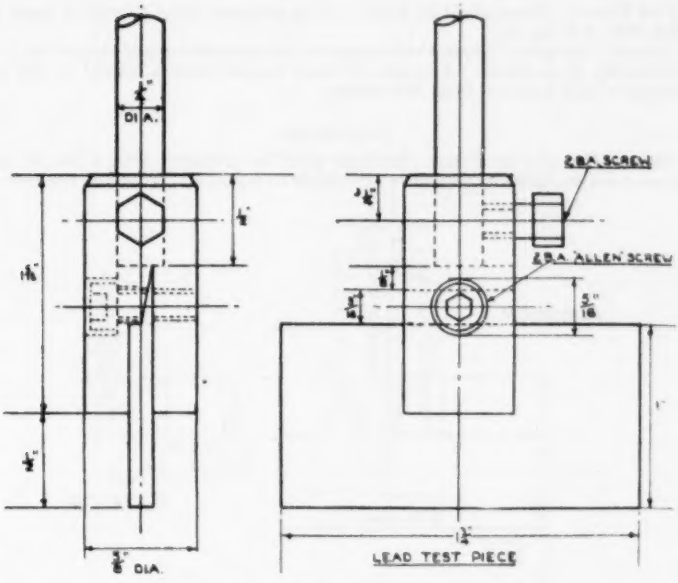


FIG. 3.
HEAD TEST-PIECE HOLDER.

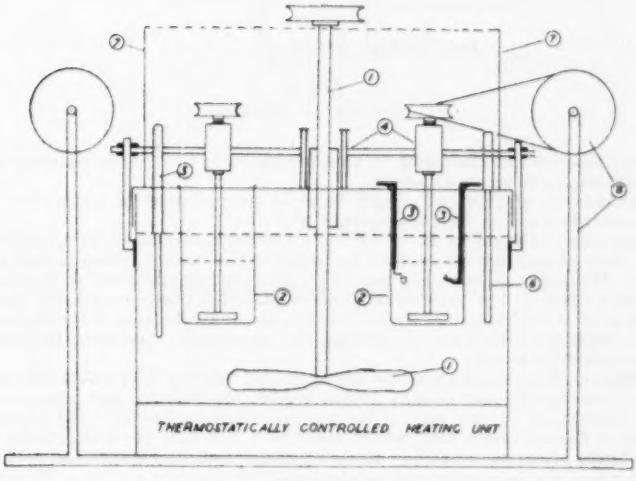


FIG. 4.
INDIANA STIRRING OXIDATION TEST UNIT.

(f) *Test Pieces.*—These shall be $1\frac{3}{4}$ in × 1 in prepared from Chemical Lead Type A to B.S.S. 334, 8 lb/sq. ft.

(g) *Copper Catalysts.*—These shall consist of electrolytic copper strips 6 in × $\frac{1}{4}$ in × approximately $\frac{1}{32}$ in thick. A length of stout copper wire is brazed to the strip for positioning in and removal from the beaker.

Procedure.

(a) *Preparation of Test Piece.*—Surfaces shall be prepared with a No. 35 Skarsten scraper to a bright finish as free from blemishes as possible. To avoid undue exposure

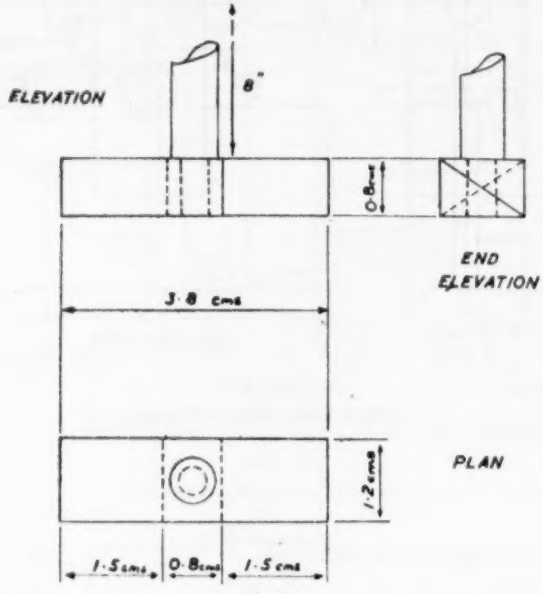


Fig. 5.

Details of stirrer.

to air the prepared test piece shall be kept immersed in I.P. petroleum spirit before and after weighing, until required for use.

(b) *Preparation of Catalyst.*—Surfaces shall be prepared in accordance with the method described in I.P. 56/46, Section 4 (*d*).

(c) *Assembly.*—400 ml at 15° C of the oil to be tested shall be weighed into the beaker. The aluminium cover shall be fitted to the beaker, using asbestos string as packing. When the oil-bath has reached a temperature sufficient to maintain the oil under test at 140° ± 1° C the beaker shall be placed in position with the thermometer arranged so that the bottom of the bulb is 1 in above the bottom of the beaker. A test specimen shaft shall be inserted through the appropriate aperture, and the catalyst aperture closed by a cork.

(d) *Method.*—The beaker shall be left in the oil bath for $\frac{1}{2}$ hr before the test is commenced. During the last 10 min of this period, the weighed test piece and catalyst shall be introduced, the top edge of the test piece being adjusted so that it is $\frac{3}{4}$ in below the level of the oil under test, which shall be 1 in below the level of the oil in the heating bath. Sitrring at 400 ± 40 r.p.m. shall then be commenced and continued for 2 hr, when the test piece and catalyst shall be changed during a 10-min interval. The test is then continued for a further 2 hr, after which the test piece and catalyst shall again be changed during a 10-min interval. After a third period of 2 hr, the test piece and catalyst shall be removed and the beaker taken from the heating bath. On the next day using the oil remaining in the beakers, an identical procedure shall be followed.

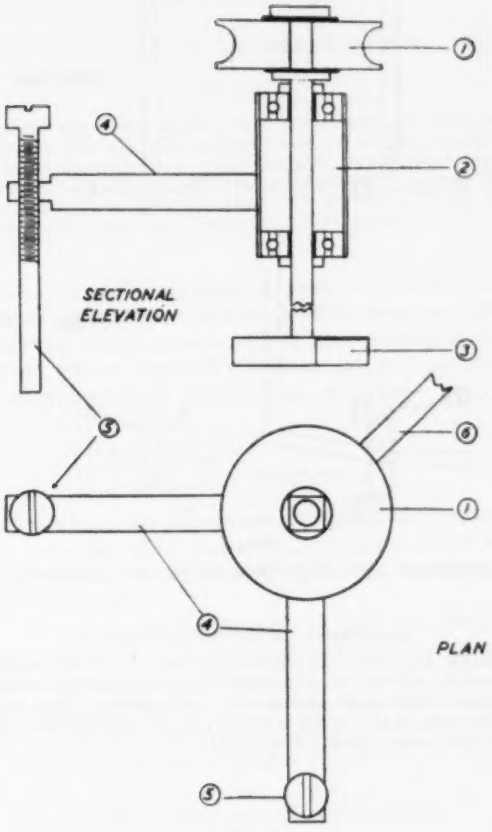


FIG. 6.
STIRRER-MOUNTING ASSEMBLY.

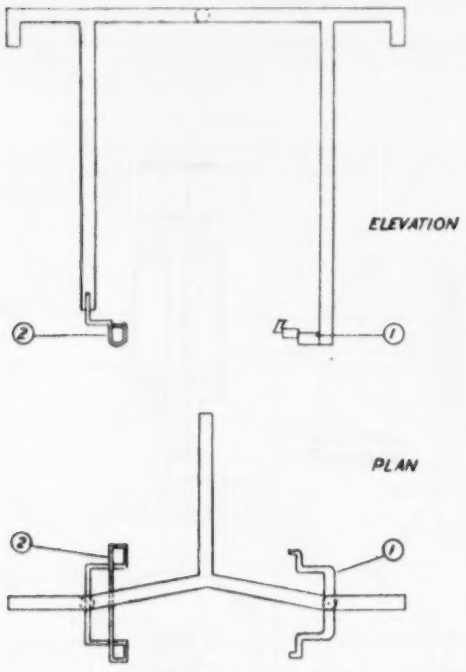


FIG. 7.

CATALYST AND TEST-PIECE SUSPENSION ASSEMBLY.

ASSESSMENT OF CORROSIVE EFFECT.

As soon as possible after the test pieces have been removed from the beaker they shall be freed from oil and any loose material by washing with benzene and by lightly brushing with a camel-hair brush wetted with this solvent. They shall then be dried and weighed. The sum of the losses in weight of the six test pieces constituting one test, expressed in milligrams, shall be recorded.

DETERMINATION OF THE WATER CONTENT OF MOTOR FUELS.

By S. J. W. Pleeth (Fellow).*

Summary.

The literature has been examined for methods of determining water contents suitable for use with motor fuels containing water-soluble constituents. Three methods have been compared in the laboratory: Dietrich (using magnesium nitride), Schutz (using calcium carbide), and Fischer (using iodine and sulphur dioxide in pyridine). Of the methods the Fischer gave the most consistently accurate results, and is recommended in preference to the remainder.

The determination of small quantities of water in water-soluble substances has long presented a problem. The method of Dean and Stark [1] functions admirably when the water is present in materials of low volatility (lubricating oil, fuel oil, grease, non-volatile alcohols), but cannot be used in the presence of volatile alcohols and similar materials used in motor-fuel blends (methanol, acetone, etc.).

Specific Gravity.

When dealing with a two-component system alcohol/water, an accurate estimation may be obtained from the determination of the specific gravity. Tables are available for a number of materials, from which the water content may be obtained.[2]

Only rarely are we fortunate enough to have so simple a system to examine. More frequently the main component is contaminated either incidentally (*e.g.*, technical grades) or deliberately (*e.g.*, denatured) in addition to adventitious water. Where the material is deliberately contaminated, as in denatured power alcohol, special specific-gravity tables are available [3] or can be prepared from a knowledge of the denaturants.

Critical Solution Temperature.

The Critical Solution Temperature (C.S.T.) of a water-soluble substance and a water-insoluble substance is extremely sensitive to water. The C.S.T. of the system methanol/*cyclo*hexane is raised by 1·35° C by the presence of only 0·2 per cent water; an accurate thermometer permitting readings to 0·1° C will detect the presence of less than 0·01 per cent of water. Vogel [6] has given C.S.T. tables for the systems wet methanol/*cyclo*hexane and wet ethanol/di*cyclo*hexyl. Similar tables can be prepared for any convenient pair of liquids.

A more general method, due to Crismer,[4] uses a blend of kerosine and petroleum ether as the water-insoluble component. The proportions of the blend are adjusted to provide C.S.T. within a convenient range of an

* Chief Chemist, Cleveland Petroleum Co. Ltd.

accurate thermometer. A standard curve is prepared using anhydrous ethanol, and ethanol containing known weights of water (in practice, blends of anhydrous ethanol and ethanol containing a known weight of water are used, permitting rapid preparation of ethanol containing accurately known amounts of water). Then the C.S.T. of the unknown material is found and the water content read from the graph. Under best conditions an accuracy of 0·01 per cent of water may be obtained.

An alternative method has been suggested by Botset [5] using anhydrous carbon tetrachloride as the water-insoluble component. A standard curve is prepared using ethanol containing known amount of water, but instead of obtaining the C.S.T., water is added from a micro-burette until the system just becomes cloudy at 60° F. The unknown material is then titrated similarly, and the water content obtained from the graph. The method is not as precise as the Crismer method given above, but is more convenient for comparatively large water contents. An accuracy of 0·2 per cent of water should be possible.

Certain motor-fuel blends containing alcohol, petrol, and sometimes benzole may be treated as a two-component system for the determination of C.S.T. A method has been tentatively suggested by the I.P. (98/44(T)) [20] for the determination of the water tolerance as defined by Ormandy [7] of such blends. Reference should be made to the Standard Methods book for details of the method; briefly, water is added from a micro-burette to 50 ml of the *undried* fuel until immiscibility occurs at 60° F. Assuming that the composition of the blend is exactly known, a similar blend is prepared using dried ingredients and a water tolerance determined. (The author has published graphs showing the water tolerances of blends of ethanol/benzole/petrol [3].) The difference between the two results is equal to the water content of the original material.

Miscellaneous Methods.

All the above methods fail for unknown and complex systems. Vavrinecz [8] has suggested drying the material with anhydrous potassium carbonate or copper sulphate, filtering, and obtaining specific gravities before and after. The water content is then given by the formula $D - d/1 - d$, where D is the sp. gr. of original spirit and d is that of the dried spirit. Unfortunately, for small amounts of water the difference between the two gravities is very small, and errors in the determination render the calculation inexact.

Hoffert and Claxton [18] have suggested a method based on the formation of the ternary azeotrope water/ethanol/benzene, containing 7·4, 18·5, and 74·1 per cent respectively of the three components. Sufficient benzene is added to the spirit to ensure the formation of this azeotrope and the mixture distilled using a good fractionating column. The fraction distilling at 64° to 85° C is collected and measured; the water content of the original volume of spirit (before the addition of the benzene) is 7·4 per cent of this fraction. This method implies a multiplying factor of 13·5, and under best conditions can provide good results. It is, however, of limited application, and cannot be used where materials such as methanol are present, which yield alternative azeotropes.

Chemical Methods.

Methods of widest application are those where the water takes part in a definite chemical reaction. One of the earliest of such methods is that of Henle [19] using certain dehydrated compounds of aluminium ethylate. The method has been perfected by Kremer,[10] who used the compound $Al_2(OC_2H_5)O$ dissolved in an organic solvent. In the presence of water, insoluble aluminium hydroxide was formed, which could be filtered and determined. The objection to this method is the comparative difficulty of preparing the reacting chemical.

Dietrich and Conrad [9] suggested the use of magnesium nitride, which yields ammonia by the action of water :—

$$Mg_3N_2 + 6H_2O = 3Mg(OH)_2 + 2NH_3 \quad . \quad . \quad . \quad (1)$$

The ammonia is distilled and absorbed in standard acid, which is back-titrated. Methanol interferes when present in excess of 40 per cent owing to the formation of NMe_3, and must be diluted to below this figure. It is stated that 1 ml of N-H_2SO_4 is equivalent to 0·006 g. water, but as there is some doubt about the equation, standard curves are obtained with ethanol of known water content.

The author, in testing this method, found great difficulty in obtaining consistent results. These inaccuracies were probably due to impurities in the magnesium nitride, and to the difficulty in preventing access of atmospheric moisture. In addition, the method is lengthy and tedious and demands constant attention. Some results are recorded in Table I. They

Table I.

Figures shown represent g H_2O.	Method.			
	Dietrich.	Schutz.	Fischer.	Miscellaneous.
Dry EtOH . .	0·010	0·018	0·008	(*a*) 0·04
EtOH + 0·010 .	0·024	0·032	0·018	—
,, + 0·029 .	0·026	—	0·034	—
,, + 0·049 .	0·082	—	0·053	(*a*) 0·10
,, + 0·097 .	0·120	0·068	0·102	—
,, + 0·146 .	0·129	—	0·152	—
,, + 0·194 .	0·143	0·132	0·202	(*a*) 0·28
C_6H_6 (wet) . .	0·020	—	0·017	(*b*) 0·012
MeOH . .	—	—	0·011	(*a*) 0·013
Fuel A . .	—	—	0·20	(*c*) 0·10
,, B . .	—	—	0·12	(*c*) 0·20
,, C . .	—	—	0·16	(*c*) 0·20

Notes.

(*a*) Determined by critical solution temperature.
(*b*) Taken from literature.[18]
(*c*) Determined by water tolerance method.[20]

are not satisfactory. Doubtless better results could be obtained by improvements in the quality of the Mg_3N_2 and by the adoption of a stricter analytical procedure.

The method of Schutz and Klauditz [11] suffers from similar procedural difficulties. It is based on the reaction :—

$$CaC_2 + H_2O = CaO + C_2H_2 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The acetylene formed is distilled into a standard solution of $CuSO_4$, forming a corresponding amount of copper acetylide. When the reaction is deemed complete, standard ferric sulphate is added to the copper sulphate solution and the amount of ferrous ion formed estimated with standard potassium permanganate. It is stated that 1 ml N-$KMnO_4$ is equivalent to 0·018 g. water.

The author found that commercial calcium carbide is of doubtful purity, and that probably equation (2) does not represent the complete reaction. Furthermore, just as the magnesium nitride of the Dietrich method always carried an ammoniacal odour, the calcium carbide used bore a strong odour of acetylene (or of those impurities that provide acetylene with its outstanding characteristic). Again like the Dietrich method it is tedious and unsuitable for routine work in a laboratory. Some results are given in Table I; they are not satisfactory.

Aubone [12] recommends that the acetylene formed be measured by direct volume. This alternative was not examined as it was thought to provide even greater experimental difficulties.

This objection also applies to the method suggested by Broche and Scheer,[17] who measured the hydrogen produced in the reaction :—

$$CaH_2 + H_2O = CaO + 2H_2 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Finally, there is the method which, in the author's opinion, is superior to those described previously and should supersede them : the method given by Karl Fischer.[13] The basic reaction is :—

$$2H_2O + SO_2 + I_2 = H_2SO_4 + 2HI \quad . \quad . \quad . \quad . \quad (4)$$

Since the reaction is reversible, pyridine is added to remove the sulphuric acid from the system; the reaction then goes to completion. The equation is not quantitative, however, and a standardization curve must be drawn using ethanol of known water content. The method has recently been investigated by Seaman *et al*,[14] who recommend certain improvements in detail. The method to be described is based on Seaman's modifications.

Methanol is dried by shaking with anhydrous copper sulphate and distilling (or better, by the activated magnesium method given by Vogel,[16] or similarly dried ethanol may be used).* To one portion a known weight of water is added (say 1 g to 100 g MeOH). By suitably blending,

---

* Dehydration of ethanol or methanol by activated magnesium (Lund and Bjerrum, 1931, from Vogel [16]).

Ethanol or methanol containing less than 0·05 per cent water may be obtained. Normal drying methods (quicklime or anhydrous copper sulphate) are first used to reduce the water content to below 1 per cent. The alcohol is then refluxed with magnesium turnings which have first been heated with iodine. The reactions are :—

$$Mg + 2C_2H_5OH = H_2 + Mg(OC_2H_5)_2 \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$Mg(OC_2H_5)_2 + 2H_2O = Mg(OH)_2 + 2C_2H_5OH \quad . \quad . \quad . \quad . \quad (2)$$

Reaction (1) occurs only when the MgI_2 is present as a catalyst.

When the reaction (2) is complete the alcohol is distilled off using a system protected from atmospheric moisture.

methanol containing an accurately known weight of water is obtained. The Fischer reagents may be purchased from the recognized suppliers or prepared as follows (the two portions should not be mixed until the actual determination) :—

Reagent A : 950 ml pyridine + 190 g liquid SO_2 dissolved in 1 litre dry methanol.
Reagent B : 60 g iodine dissolved in 2 litres dry methanol.

10 ml dry methanol are pipetted into a dry 50-ml flask and 10 ml reagent A added by means of an automatic pipette. The mixture is titrated with reagent B as quickly as possible, to reduce access of atmospheric moisture, until the original yellow colour changes to brown.

Similar titrations with the methanol of known water contents rapidly provide a standardization graph.

Finally, the unknown solutions are titrated, and from the graph, the water contents may be read directly. In the concentrations used by the present author a titration of 1 ml reagent B was equivalent to 0·006 g water, which indicates the extreme sensitivity of the method.

The reagents change very slightly in storage (about 1 per cent each week) and should be standardized at intervals. The method is rapid (once the reagents are standardized) and eminently suitable for routine work. Dyed fuels (*e.g.*, commercial petrol) somewhat obscure the end-point, and they must be diluted with dry ethanol until the colour does not interfere. Bonner has suggested a potentiometric method which permits the titration of dyed and heavily coloured materials.[15]

A number of results are given in Table I.

Conclusions.

The results obtained by the Dietrich method were inconsistent; the figures shown are sometimes averages of two or more tests.

Few determinations were made with the Schutz method, as it was seen to be as inconsistent as the Dietrich.

The results obtained by the Fischer method were consistent and repeatable. Each determination took but a minute or two against the hour or more with the other two methods.

The Fischer method for the determination of water must be recommended to the exclusion of the other methods examined.

References.

[1] I.P. Method 74/45.
[2] "International Critical Tables," McGraw-Hill.
[3] Pleeth, S. J. W. "Alcohol," Chapman & Hall, 1948.
[4] Crismer. *Chem. Zent.*, 1904, **1**, 1479.
[5] Botset, H. G. *Industr. Engng Chem.*, 1938, **23**, 6.
[6] Vogel, A. "Practical Organic Chemistry," p. 21, Longmans, 1948.
[7] Ormandy, W. R. *J. Inst. Petrol. Techn.*, 1934, **20**, 126.
[8] Vavrinecz. *Vagyi Ipar*, 1930, **29** (4), 3–4.
[9] Dietrich, —, and Conrad, —. *Z. Angew. Chem.*, 1931, **44**, 532.
[10] Kremer, —. *Petrol. Z.*, 1931, **27**, 443.
[11] Schutz, —, and Klauditz, —. *Z. Angew. Chem.*, 1931, **44**, 42.
[12] Aubone, —. *Bol. Inf. Petrol. (Arg.)*, 1944, **21** (236) 15.
[13] Fischer, —. *Z. Angew. Chem.*, 1935, **48**, 394.

[14] Seaman, W., *et al.* *Anal. Chem.*, 1949, **21**, 411.
[15] Bonner, —. *Analyst*, 1946, **71**, 483.
[16] Vogel, A. "Practical Organic Chemistry," p. 165, Longmans, 1948.
[17] Broche, —, and Scheer, —. *Brenn. Chem.*, 1932, **13**, 28.
[18] Hoffert, W. H., and Claxton, G. National Benzole Assoc., 1938. "Motor Benzole : Its Production and Use."
[19] Henle, —. *Ber.*, 1920l **53**, 719.
[20] I.P. Method 98/44 (T).

THE INSTITUTE OF PETROLEUM.

ANNUAL REPORT

For the Year Ending December 31, 1949.

Deaths.

Council regrets to record the deaths of the following members :—

A. T. Beazley (*Member of Council*)	Fellow.
R. J. Black	Member.
F. Bergius	Honorary Member.
P. F. Finnigan	Member.
A. J. Henderson	Member.
W. H. Hoffert	Fellow.
W. F. Hume	Fellow.
A. G. Hutchison	Fellow.
W. G. Langford	Member.
F. Middleton	Member.
W. Miller	Fellow.
R. A. Thomas	Honorary Member.

Membership.

Details of membership as at December 31, 1949 :—

	Total Dec. 31, 1948.	Changes during 1949.						Total Dec. 31, 1949.
		New.	Transferred to.	Resigned.	Deceased.	Transferred from.	+ or −.	
Hon. Members	11	—	—	—	2	—	− 2	9
Hon. Fellows	3	—	—	—	—	—	—	3
Members	622	32	1	1	5	11	+ 16	638
Fellows	512	28	16	33	5	—	+ 6	518
Assoc. Members	714	82	2	12	—	19	+ 53	767
Assoc. Fellows	181	132	24	16	—	1	+139	320
Students	204	24	—	22	—	12	− 10	194
Totals	2247	298	43	84	12	43	+202	2449
Member-Companies	60	90	—	—	—	—	+ 90	150

There has been a gratifying increase in the corporate membership of the Institute, and Council hope there will be even more substantial gains in 1950. All members are invited to encourage their colleagues in the industry who are suitably qualified to apply for membership, since a strong corporate membership is fundamental to the progress of the Institute.

Council attaches much importance also to the support of Member-Companies, and the increase in this category in 1949 is most encouraging.

General.

Nine Ordinary General Meetings of the Institute were held during 1949, the September Meeting being a Joint Meeting with the Institution of Fire Engineers.

A very successful Dinner was held at the Savoy Hotel in February, when over 450 members and guests attended.

During the year the offices and lecture hall at Manson House have been redecorated, and new furniture and lighting and heating fittings have been purchased for the Library, which is now much more comfortably furnished.

The canteen has run very smoothly, and the facilities have been much appreciated by the staff and by members of committees and panels.

There has been one addition to the staff during the year, and one change in personnel.

The details of a Staff Pension Fund have been agreed, and this came into being on January 1, 1950.

A design for the Crest submitted by the Royal College of Heralds was approved, and has attracted much favourable comment. The thanks of the Institute are due to Mr J. S. Parker, who provided the basis for the design.

Aviation Products Data.

This Committee was formed to collaborate with the Royal Aeronautical Society in the preparation and publication of data sheets on aviation fuels, lubricants, hydraulic fluids, and de-icing fluids, giving information on specifications, composition, and properties of these products in as much detail as possible, and in a form convenient for reference.

The first part of the assignment has been completed, and the data sheets on aviation fuels are now being printed.

Benevolent Fund.

There was one call on the Benevolent Fund during the year, a substantial grant being made to the widow of a member, and it is hoped members will continue to support this fund so that an adequate reserve can be built up against all eventualities.

Branches and Students' Section.

The work of the Institute in the branches has the strongest support from Council, since this provides local facilities which would otherwise be denied the provincial member.

The total Branch membership at the end of 1949 was as follows :—

Corporate Members	655
Student Members	50
Branch Members	450

A new Branch was inaugurated at Fawley, and the London Branch, formed in 1948, became well established and has an expanding and active membership.

In the Northern Branch during the latter part of the year, corporate membership was made a condition of membership of the Branch, and this resulted in a substantial increase in corporate membership in the north.

The Birmingham students' section, which is associated with the University Chemical Engineering Society, is the only student section at present in being, and Council welcomes the activities of this group.

Engineering.

The revision of the Institute's Electrical Code was completed, and the revised code is in the hands of the printer.

During the year Council agreed to work being undertaken on a model code of safe practice in the petroleum industry, and three sub-committees were formed covering production, refining, and distribution and marketing. The preliminary work has already been started.

Practical field tests were put in hand to obtain information on the extent of dangerous areas surrounding dangerous locations, and a great deal of data have been collected on this subject from areas all over the world.

Finance.

The steps taken during the year to secure increased income proved effective. Increases in all categories of Corporate Membership raised the income from this source by more than £1000.

The enrolment of Member-Companies gathered momentum during the year, and the income from 150 members in this class amounted to £7368.

Office accommodation, including the additional space acquired towards the end of 1948, cost nearly £2000 more in 1949; the extension of our activities and catering for a steadily rising membership raised our salary bill by another £2000. The timely and valued support by the new Member-Companies not only enabled us to meet these increased financial commitments but also resulted in our showing a credit balance in our Income and Expenditure Account.

During the year, the members at a Special General Meeting agreed to an increase in Corporate Members' subscriptions to meet the increase in costs of providing the Institute's publications and services. The new subscriptions became effective on January 1, 1950.

The Finance Committee gave attention to a claim from the Inland Revenue that the Institute, in view of certain decisions in High Court cases, could no longer be exempt, as a charity, from income tax. Steps are being taken to effect certain changes in our Memorandum of Association which, while not affecting our primary aims and objects nor curtailing our activities, would re-admit us as a Charity.

Publications.

Journal.—Volume 35 of the *Journal* was published in twelve monthly parts, and consisted of 847 pages (940 pages in 1948) of *Transactions*, 412 pages (402 pages in 1948) of *Abstracts*, and the usual title pages and indexes.

The transactions consisted of forty-nine individual papers, their broad classification being :—

Production	2
Refining	3
Physics and chemistry	22
Analysis and testing	13
Transport and storage	3
Fire extinction	3
Utilization	2
Oil shale	1

The number of abstracts published during the year was 1853, compared with 1883 in 1948, and the details of main classes follow :—

	1948.		1949.	
	No.	Per cent.	No.	Per cent.
Exploration and exploitation	686	36·4	461	24·9
Transport and storage	93	4·9	101	5·5
Refining operations	323	17·2	398	21·5
Products	600	31·9	651	35·1
Engines and equipment	112	6·0	115	6·2
Miscellaneous	69	3·6	127	6·8
Total	1883	100·0	1853	100·0

I.P. Review.—Volume 3 of the *I.P. Review* was published in twelve monthly parts, with a total of 396 pages (380 in 1948) plus title pages.

In general, there was no lack of material for this publication, which included thirty-six signed articles on a wide variety of subjects considered likely to interest members. In addition, many matters of interest were brought to the notice of members as news items and extracts from matter published elsewhere.

The companies have been most helpful in supplying news items and photographs.

During 1949 an assistant was provided to : (*a*) relieve the advertisement manager of certain editorial work, and (*b*) to assist the editor.

Research.

The work of the Hydrocarbon Research Group has been expanded during the year by the inclusion of workers at the Dyson Perrins Laboratories, Oxford. Good progress has been made in the fields of hydrocarbon synthesis under study and the Synthesis Panel presented a review of their programmes to the Institute on November 9, 1949. A symposium on Mass Spectrometry is being sponsored by the Mass Spectrometry Panel in April 1950. Spectroscopic work has also been actively pursued. The work of the Committee No. 2 on carcinogenic activity has been linked with similar work by the Medical Research Council. A detailed programme of investigation has been accepted, and preliminary work is in progress.

The Research Committee have considered ways and means of expanding the research work sponsored by the Institute. Several fields have been suggested, including behaviour of hydrocarbon systems under high pressure,

problems of lubrication, kinetics of hydrocarbon decomposition, and flame propagation. There appears to be ample scope for expansion, and the universities are willing to co-operate. Research work of this nature is, however, expensive, and the Committee have considered the desirability of expanding the company-sponsored programmes.

Standardization.

Relations with A.S.T.M. have been cemented through a visit to this country by A.S.T.M. representatives last June, and also during the visit of the President to the U.S.A., when he attended the A.S.T.M. meeting at San Francisco, October 10–14, and had many cordial and useful discussions with A.S.T.M. members. A.S.T.M. and I.P. are also co-operating in the joint preparation of a series of oil-measurement tables.

Attention is being given to the possibility of writing standard methods in such a way that they would be applicable in countries using different units of measurement, which should assist in achieving international standardization.

The growing importance of statistical methods in the treatment of precision data is recognized by the inclusion of an appendix on this subject in the 1949 edition of " Standard Methods."

Acknowledgments.

Once again, Council wishes to record its appreciation of the loyal service of the staff of the Institute. The senior members of the staff have all been under heavy pressure throughout the year, and the fact that Council has such a successful year to report is in no small measure due to their efforts.

By Order of the Council,
March 1950 C. Chilvers, Hon. Secretary.

P. Dumanois

It is much regretted that in the Annual Report as circulated to members M. Paul Dumanois was wrongly shown as having died during the year.

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET A

CAPITAL AND RESERVES.

	£ s. d.	£ s. d.	£ s. d.	*194* £
Capital of the Institute under Bye-Laws 36, 44, and 45 :—				
Life Membership Fund—	£ s. d.			
As at December 31, 1948	919 4 0			*91*
Add Subscriptions during year	20 2 6			
		939 6 6		
Entrance and Transfer Fees—				
As at December 31, 1948	5235 19 9			
Add Receipts during 1949—				
Entrance Fees	401 2 0			
Transfer Fees	16 16 0			
		5653 17 9		*523*
Profit on Sale of Investments—				
As at December 31, 1948		257 19 4		*25*
Donations—				
As at December 31, 1948		326 5 0		*32*
			7177 8 7	*673*
T. C. J. Burgess Prize Fund			5 0 0	
General Reserve (previously War Contingencies Reserve)			1702 0 11	*170*
Revenue Account :—				
As at December 31, 1948		2597 13 4		
Add Surplus for the year as per attached account		3083 6 2		
			5680 19 6	*259*
			14,565 9 0	*11,04*
Subscriptions Received in Advance :—				
Members' Subscriptions for 1950		1211 3 0		
Member-Company Subscriptions for 1950		2025 10 0		
Journal Subscriptions for 1950		905 9 11		
Subscriptions for 1951 and 1952		32 3 10		
			4174 6 9	*234*
Current Liabilities :—				
Sundry Creditors and Accrued Charges		1263 19 7		
World Petroleum Congress		280 5 2		
Taxation		85 3 2		
			1629 7 11	*151*

[*Note.*—The taxation position has not yet been determined, and some adjustments may be required.]

Approved by Council :
E. A. EVANS, President.
G. H. COXON, Hon. Treasurer.

£20,369 3 8 *£14,895*

REPORT OF THE AUDITORS TO THE MEMBERS OF

In our opinion and to the best of our information, and according to the explanations given to us, affairs as at December 31, 1949, and the Revenue Account gives a true and fair view of the result the best of our knowledge and belief were necessary for our audit. In our opinion, the Institute with, give in the prescribed manner the information required by the Companies Act, 1948.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C. 2.
April 6, 1950.

OF PETROLEUM.

nd not having a Share Capital.)

T DECEMBER 31, 1949.

					1948
FIXED ASSETS.	£ s. d.	£ s. d.			£
nvestments :—					
On Account of Capital, at cost—					
£525 0 0 3% Savings Bonds, 1955/65	525 0 0				
867 8 6 2¾% Bristol Corporation Redeemable Stock, 1955/65	845 17 7				
150 0 0 3% Smethwick Corporation Redeemable Stock, 1956/58	151 4 9				
150 0 0 3% Luton Corporation Redeemable Stock, 1958	151 6 7				
806 8 3 3% Manchester Corporation Redeemable Consolidated Stock, 1958	845 17 7				
600 0 0 3% Bristol Corporation Redeemable Stock, 1958/63	597 7 3				
664 6 6 3% London County Consolidated Stock, 1920	481 10 6				
400 0 0 3% Metropolitan Water Board "A" Stock, 1963	346 10 7				
193 0 0 3% British Gas Guaranteed Stock, 1990/95	154 8 6				
156 9 8 3% British Transport Guaranteed Stock, 1978/88	105 4 9				
461 0 0 2½% Funding Loan, 1956/61	461 15 6				
500 0 0 2½% Defence Bonds	500 0 0				
(Market Value at December 31, 1949, £5156.)	5166 3 7				*5166*
Cash awaiting Investment on Deposit with Post Office Savings Bank	1573 4 6				*1573*
		6739 8 1			
On Account of Revenue, at cost—					
£475 0 0 3% Savings Bonds, 1955/65	475 0 0				
2000 0 0 3% Savings Bonds, 1960/70	2000 0 0				
		2475 0 0			*2475*
(Market Value at December 31, 1949, £2413.)					
Office and Library Furniture at cost, less amounts written off :—					
As at December 31st, 1948	873 5 5				
Add Additions during 1949	316 17 0				*873*
	1190 2 5				
Less Depreciation provided for year to date	119 0 3				
		1071 2 2			
		10,285 10 3			*10,087*
Current Assets :—					
Stock of Literature in Hand	1568 5 0				
Sundry Debtors and payments in advance, including Income Tax recoverable to date	2708 10 8				*1416*
Subscriptions in arrear (not valued)	—				
Cash at Bank on Current Account and in hand	3543 4 8				*1222*
Cash on Deposit with Post Office Savings Bank—					
General Account	1983 7 11				*1897*
World Petroleum Congress	280 5 2				*273*
		10,083 13 5			
		£20,369 3 8			*£14,895*

THE INSTITUTE OF PETROLEUM.

he Balance Sheet, with the note thereon, gives a true and fair view of the state of the Institute's or the year ended on that date. We have obtained all the information and explanations which to as kept proper books of account, and the above mentioned accounts, which are in agreement there-

PRICE, WATERHOUSE & CO.,
Chartered Accountants.
Auditors.

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£	s.	d.	£	s.	d.	*1948* £
To **Administrative Expenses :—**							
Staff Salaries and National Insurance	7269	7	1				*5109*
Printing and Stationery	738	1	4				*989*
General Postages	429	16	2				*119*
Telephones, Cables and Travelling Expenses	230	9	3				*120*
Audit Fee	73	10	0				*73*
Legal Fees	30	4	6				*107*
General Expenses	377	15	1				*659*
Insurance	33	4	0				—
				9182	7	5	
,, **Establishment Expenses :—**							
Rent, less amounts recovered	2500	0	0				*836*
Cleaning, Lighting and Heating	413	5	1				*236*
				2913	5	1	
,, **Publications Expenses** (see separate account).							*6273*
Dispatch Expenses							*589*
,, **Meetings :—**							
Hire of Hall, Pre-Prints, Reporting, etc.				379	5	0	*440*
,, **Branches and Sections :—**							
Scottish Branch	46	15	0				
Northern Branch	136	4	0				
South Wales Branch	48	2	6				
London Branch	59	5	0				
Stanlow Branch	77	18	6				
Trinidad Branch	76	5	0				
Birmingham Section	20	0	0				
				464	10	0	*335*
Sundries :—							
Library Expenses	114	10	10				
Subscriptions to Societies	63	8	0				
Scholarship Awards	100	0	0				
Depreciation of Furniture (10%)	119	0	3				
Taxation for 1947—not recoverable	72	10	10				
Taxation for 1949	137	19	0				
				607	8	11	*634*
Balance, being Excess of Income over Expenditure				3083	6	2	—
				£16,630	2	7	*£16,519*

OF PETROLEUM.

YEAR ENDED DECEMBER 31, 1949.

	£	s.	d.	*1948* £
By Members' Subscriptions received for 1949	6291	7	0	*5383*
,, Members' Subscriptions in Arrear, received during year	360	11	9	*94*
,, Member-Company Subscriptions received for 1949	7368	7	6	
,, Special Subscription	20	0	0	*20*
,, Publications Account—surplus	2250	3	2	—
,, Interest and Dividends received (Gross)	321	10	8	*344*
,, Amounts recoverable from Branches (including Refund £18 2*s.* 6*d.* from South Wales)	18	2	6	*33*
,, Balance, being Deficit for the Year carried to Balance Sheet	—			*1311*
,, Publications Receipts (see separate account)	—			*9334*
	£16,630	2	7	*£16,519*

Surplus from Publications Account £2250 3*s.* 2*d.* *Note.*—In previous years, no value has been placed on stock of publications in hand.

PUBLICATIONS ACCOUNT.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1949.

	£	s.	d.		£	s.	d.
To **Stock in hand at January 1, 1949 (not valued)**				By **Advertising**	3791	15	4
,, **Dispatch Expenses**	328	16	8	,, **Journal**	1994	4	1
,, **Journal**	4702	17	3	,, **I.P. Review**	265	16	1
,, **I.P. Review**	1851	8	0	,, **Standard Methods**	1934	0	0
,, **Abstracts**	248	4	0	,, **Reviews of Petroleum Technology**	608	0	0
,, **Standard Methods**	848	0	4	,, **Other Publications**	1145	4	5
,, **Modern Petroleum Technology**	14	7	11	,, **Profit on Exchange**	70	8	6
,, **Reviews of Petroleum Technology**	1140	17	8	,, **Non-returnable Fees**	64	11	4
,, **Tables for Measurement of Oil**	1	10	6	,, **Stock in hand at December 31, 1949**	1568	5	0
,, **Other Publications**	55	19	3				
	9192	1	7				
,, **Balance**	2250	3	2				
	£11,442	4	9		£11,442	4	9

CADMAN MEMORIAL FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1949.

	£	s.	d.		£	s.	d.
To **Balance at December 31, 1949 :—**				By **Balance at December 31, 1948**	2960	1	1
	£	s.	d.	,, **Interest received and tax recoverable during year**	176	1	6
Cash at Bank on Current Account	377	15	7				
£2730 3% Savings Bonds, 1965/75 (Market Value at December 31, 1949, £2593)	2730	0	0				
Payment for medals	28	7	0				
	3136	2	7				
	£3136	2	7		£3136	2	7

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund, and find it to be in accordance therewith. We have verified the cash with Bankers to be in accordance with the balance on December 31, 1949.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C. 2.
April 6, 1950.

PRICE, WATERHOUSE & Co.,
Chartered Accountants.
Auditors.

HYDROCARBON RESEARCH GROUP.

Income and Expenditure Account for the Year ended December 31, 1949.

	£ s. d.	£ s. d.		£ s. d.
To **Grants :—**			By **Balance at December 31, 1948** . . .	756 9 2
King's College	300 0 0		„ **Voluntary Contributions received from Members of the Group during the year** .	6000 0 0
University of Oxford . .	1200 0 0			
University of Birmingham .	872 10 5			
Bedford College . . .	1300 0 0			
Queen Mary College . . .	564 19 7			
		4237 10 0		
„ **Honoraria**		934 15 1		
„ **General Expenses** . . .		95 17 6		
„ **Wages**		268 9 0		
„ **Balance at December 31, 1949, represented by cash at Westminster Bank, Limited** . .	1488 6 7			
Less Sundry Creditors, Institute of Petroleum . .	268 9 0			
		1219 17 7		
		£6756 9 2		£6756 9 2

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund, and find it to be in accordance therewith. We have verified the cash with Bankers to be in accordance with the balance on December 31, 1949.

3, Frederick's Place,
Old Jewry, London, E.C. 2.
April 6, 1950.

Price, Waterhouse & Co.,
Chartered Accountants.
Auditors.

CARCINOGENICITY RESEARCH FUND.

Income and Expenditure Account for the Period ended December 31, 1949.

	£ s. d.		£ s. d.
To **Balance at December 31, 1949, represented by Cash at Westminster Bank, Limited** .	2000 0 0	By **Cash received from the Petroleum Board (during 1947) on account of research at Birmingham University**	2000 0 0
	£2000 0 0		£2000 0 0

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund, and find it to be in accordance therewith. We have verified the cash with Bankers to be in accordance with the balance on December 31, 1949.

3, Frederick's Place,
Old Jewry, London, E.C.2.
April 6, 1950.

Price, Waterhouse & Co.,
Chartered Accountants.
Auditors.

BENEVOLENT FUND.

Receipts and Payments Account for the Year ended December 31, 1949.

Receipts.	£ s. d.	£ s. d.	*1948* £
Balance at December 31, 1948		2642 13 4	*2481*
Receipts during 1949 :—			
Subscriptions and Donations	92 13 10		*204*
Interest, gross	55 5 0		*57*
		147 18 10	
		£2790 12 2	*£2742*

Payments.	£ s. d.	*1948* £
Grant paid	50 0 0	*100*
Balance at December 31, 1949	2740 12 2	*2642*
	£2790 12 2	*£2742*

The Balance at December 31, 1949, was held as follows :—

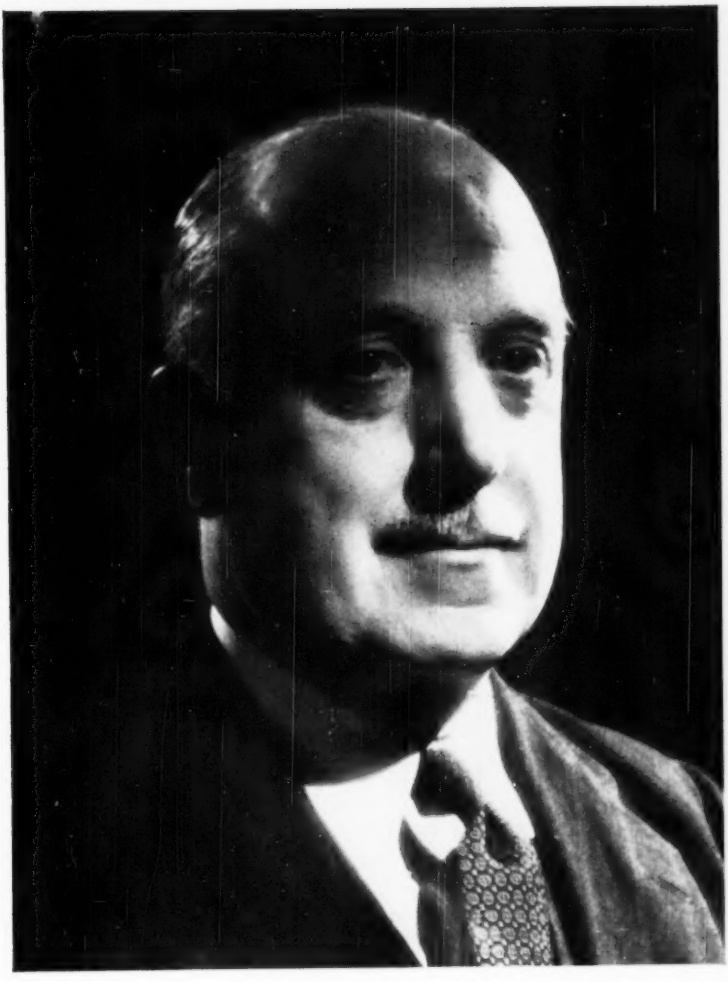
	£ s. d.
Cash at Bank on Current Account	640 12 2
£550 3% Defence Bonds *	550 0 0
£1550 2½% Defence Bonds *	1550 0 0
	£2740 12 2

* (Market value at December 31, 1949, £2100.)

We have examined the above Receipts and Payments Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the Investments and the Balances with Bankers and The Institute of Petroleum comprising the Balance on December 31, 1949.

3, Frederick's Place,
Old Jewry, London, E.C. 2.
April 6, 1950.

Price, Waterhouse & Co.,
Chartered Accountants.
Auditors.



C. A. P. SOUTHWELL, M.C., B.SC.

[*To face p.* 362.

THE INSTITUTE OF PETROLEUM.

THIRTY-SEVENTH ANNUAL GENERAL MEETING.

THE Thirty-seventh Annual General Meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1, on Thursday, April 20, 1950. The President, Mr E. A. Evans, being in the Chair.

Following the reading of the notice convening the meeting, the General Secretary (D. A. Hough) read the minutes of the Thirty-sixth Annual General Meeting, the Special General Meeting of May 11, 1949, and the Special General Meeting of February 27, 1950. They were confirmed and signed.

OFFICERS FOR THE SESSION 1950–51.

President.

THE CHAIRMAN announced the Council had nominated Mr C. A. P. Southwell as President for the session 1950–51, and he had very much pleasure in proposing that that nomination be accepted.

MR T. DEWHURST seconded, and the proposition was carried unanimously.

Vice-Presidents.

The following were nominated by the Council as vice-presidents and, on the proposal of the chairman, seconded by Mr E. L. Bass, they were elected unanimously :—

M. A. L. Banks	J. S. Parker
E. J. Dunstan	H. C. Tett
F. Morton	

Members of Council.

THE GENERAL SECRETARY announced that the following had been elected by ballot to fill the ten vacancies on the Council :—

E. B. Evans	G. H. Smith
J. G. Hancock	G. H. Thornley
E. LeQ. Herbert	H. de Wilde
H. Hyams	A. T. Wilford
H. E. F. Pracy	C. S. Windebank

THE CHAIRMAN formally declared the names a valid election.

Hon. Treasurer.

MR H. HYAMS proposed that Mr G. H. Coxon be elected as Hon. Treasurer, and said he took that opportunity of thanking him for his efforts during the past year.

MR H. C. TETT seconded, and the proposition was carried unanimously.

Hon. Secretary.

The re-election of the Hon. Secretary, Mr C. Chilvers, was proposed by Mr F. L. Garton, who said he was sure he was voicing the opinion of them

all when he said Mr Chilvers had been a most assiduous and efficient honorary secretary.

MR D. L. SAMUEL seconded, and the motion was carried unanimously.

Ex-Officio Members of Council.

THE CHAIRMAN announced that the following had been nominated as ex-officio Members of Council, and he proposed their election :—

A. G. V. Berry	*Stanlow Branch*
N. E. F. Hitchcock	*London Branch*
E. J. Horley	*S. Wales Branch*
I. McCallum	*Fawley Branch*
T. W. Ranson	*Northern Branch*
W. M. Stirling	*Scottish Branch*

MR F. L. GARTON seconded, and the proposition was carried unanimously.

THE CHAIRMAN said it was important that they should have those ex-officio members on the Council, because they kept them in touch with the branches.

MEMBERS ELECTED AND TRANSFERRED.

Lists of Honorary Members, Honorary Fellows, Members, Fellows, Associate Members, Associate Fellows, Students, and Member-Companies elected or transferred during the year 1949 were then formally presented and accepted.

REPORT OF COUNCIL, 1949.

Presenting the Report of the Council for the year 1949 the Chairman said that he did not propose to consider it in detail, as it had been circulated to every corporate member. He was almost going to say that they should accept it without any comment at all, but that would be ungracious.

He felt that their initial thought would be of regret at the loss by death of a certain number of members who had helped them in the past. He did not suggest they should make any formal recognition, as that had already been done, but he suggested a thought for those who had passed on would be a kindly action.

Their membership now stood at a total of 2448, and he thought that was the first time at which they had been able to express their appreciation that the number of Member-Companies had risen to 150. They had given the Institute enormous support, and the Institute was very grateful for it.

The activities of the Institute were very healthy indeed, but he was not quite sure whether he could say that about the Benevolent Fund, which was almost stationary.

The branches were extremely active in various parts of the world.

Finance was a subject which would be dealt with separately. Studentship was still very healthy, but he was sorry to say that they had to rely for a good deal of assistance from the very willing members of it.

Finally it might be a matter of form, but he did not wish anyone to feel it that way, the Council wished to record its appreciation of the loyal services of the staff of the Institute. The senior members of the staff had all come under heavy pressure during the year, and the fact that the Council had such a successful year to report was in no small measure due to their efforts.

That was a general statement, but before his term of office terminated he

would like to make special reference to the work done by their General Secretary, Mr Hough.

There were also the other members of the staff—their old friends George Sell and Peter Kerr, and their colleagues. He proposed a very hearty vote of thanks to those members of the staff.

He asked them to accept the Report of Council, which, at that stage, did not include the Balance Sheet.

Mr C. Chilvers seconded that proposal, and the motion was carried unanimously.

Balance Sheet.

The Chairman then called on Mr G. H. Coxon, the Hon. Treasurer, to present the Balance Sheet.

Mr Coxon said his task was a simple one on the present occasion. Figures were always very dull things and he did not propose to give them in any detail, but there were one or two things in which he thought they would be interested.

The principal one was to express their grateful thanks to the Member-Companies for support they had given. It had changed the Institute from one which was financially embarrassed to one which was in a prosperous condition.

During the past few years they had had to draw on their reserves to keep them going, and it was their desire to build up that reserve again, so that while the Profit and Loss statement showed that they had a theoretical surplus of £3000, it was not cash but was partly the writing-up on paper of stocks of books and other things; but it did show a healthy state.

He was sure he was expressing the thanks of Council when he said to the Member-Companies, "Thank you for the help you have given us."

Many might criticize the raising of membership subscription when they were turning the corner, but at the time they did not know they were turning the corner. The Institute was rendering a bigger service than ever before. They had only to look at the Balance Sheet, which showed £17,000 this year as against £14,000 last. It showed the work which was going into the Institute, and how things were. He proposed the adoption of the accounts.

Mr F. L. Garton seconded that the accounts as presented be received and adopted.

The motion was unanimously adopted.

Before proceeding to the next business Mr Coxon said he would not like to close that matter without saying a word of thanks to Mr Hyams and the Finance Committee, who had done so much in getting the finances on a firmer footing. It was not easy to raise £7000, and it took a great deal of work.

Appointment of Auditors.

Mr G. H. Coxon said that, heretofore, they had on several occasions to apologize for not being able to present the accounts at the Annual General Meeting. On the present occasion they had just been able to do it by a narrow margin. The reason was that their auditors, who had given excellent service, had too much work on their hands to deal with an

Institute such as theirs. The Council had come to the conclusion some time ago that it would be advisable to change their auditors. The Finance Committee therefore recommended that Messrs Grahams, Rintoul, Hay, Bill & Co., should be appointed auditors for 1950 at a fee to be arranged by Council, and he proposed that this be done.

This was seconded by Mr C. Chilvers and carried unanimously.

Other Business.

Mr James Kewley said he wished to present to the Institute two copies—the first and second editions—of "The Petroleum Handbook." The first was autographed by the authors of the various chapters.

The Chairman said he was sure he was expressing the grateful thanks of the Institute to Mr Kewley for his kindness. The books would be given a place of pride in their library, and would assist them to remember the great work which Mr Kewley had done for the Institution.

Presentation of Honorary Fellowship to Mr James Kewley.

H. C. Tett: The Awards Committee recently unanimously concluded and recommended to Council that Mr James Kewley should be awarded the Honorary Fellowship of the Institute. It was my pleasure as Chairman of the Awards Committee to convey this recommendation to Council, which I did with the utmost confidence.

It is with very great humility that I speak now to members of the Institute of Mr Kewley's obvious qualifications for this honour. Many here know him better than I do and had the privilege of working with him many years before I knew him.

Mr Kewley joined the petroleum industry in 1906, and in his early days saw service in many parts of the world including Borneo, Egypt, and America. During the first world war he was directly concerned with the production in England and in France of toluene from petroleum, and after the war visited Roumania to report on the condition of war-damaged oil refineries. In 1919 he became chief chemist of his group of companies, and set up the first central laboratories for that group. The technical strength of the organization for which he worked was, and is, a living tribute to his enthusiasm and leadership.

Since his retirement he has continued to give freely from his vast knowledge and experience. During the last war he travelled extensively, lecturing to troops on oil at the request of the War Office.

It was characteristic of Mr Kewley that he became one of the Original Members of the Institute in 1914 and from that day took an active interest in its work. He was particularly active in connexion with standardization, was the first chairman of the sub-committee concerned with the measurement of oil in bulk, and was appointed an Honorary Member of Committee D.2 of the A.S.T.M. It is to him that we owe the inauguration of the co-operative work in this field with the A.S.T.M. which has produced such fruitful results.

He was the first chairman of the Branches Committee, which, since its formation, has done so much to co-ordinate and encourage our branch activities.

Mr Kewley was a vice-president of the Institute for many years, and became president nearly twenty years ago, in 1931. It was during his presidency that much of the planning for the first World Petroleum Congress in London in 1934 was done. He devoted all his energies towards the undoubted success of this event, and was chairman of the Committee of the Congress. Mr Kewley was succeeded in office as president by Mr Dewhurst, who, after being inducted by Mr Kewley, proposed a vote of thanks to him in which he used these words :—

> *" It is indeed fortunate for us that Mr Kewley has been our president during the worst period of the depression for, although he is alive to real dangers, he is by nature oblivious of those difficulties and troubles that never happen. He cheerfully undertakes the impossible and achieves it by unflagging effort. The results of this spirit are to be seen on every hand. He had no difficulty in leading us, for his firmness was all the more effective and impressive by reason of the fact that it was exercised only when necessary. He worked so hard that he simply carried us all along with him. The keynote of Mr Kewley's presidency has been co-operation."*

I re-read with great pleasure last night Mr Kewley's presidential address in 1932 entitled quite simply and characteristically " Co-operation." It is as alive and true to-day as it was nearly twenty years ago when it was written. I commend its wisdom and philosophy to any of you who find yourself in the library with a little time to spare.

I know from personal experience and from that of my friends that Mr Kewley was always accessible to the most junior member of his staff and of the Institute. His advice was always freely given, and because of its soundness was usually accepted.

It is a great pleasure to all of us to have him with us again to-day at a meeting of the Institute and to renew our contact with one of our elder statesmen and with a real kind-hearted gentleman.

In asking him to accept the Honorary Fellowship of the Institute we are adding a worthy name to an already distinguished list, and we are conscious of the fact that in accepting this honour Mr Kewley is honouring the Institute.

THE CHAIRMAN then asked Mr Kewley to accept the Honorary Fellowship and to sign the Institute Book of Awards.

MR KEWLEY thanked them very much for the honour they had conferred on him.

PRESIDENTIAL ADDRESS.

THE PRESIDENT delivered his presidential address, as follows :—

GREASE.

By E. A. EVANS (President).

NOTWITHSTANDING the able brains and the picturesque work which has been applied to the elucidation of friction, it still remains obscure. Theories there have been, and theories there will be until the truth ultimately emerges. Obviously, it would be an advantage to know the hidden

secrets of the thing which lubrication is trying to conquer, and must conquer if industry and pleasure are to continue. But, as lubrication has met the needs of man with reasonable success throughout the ages, a little delay in the elucidation of friction will not affect seriously economic progress. Oils and greases have attained a standard comparable to the demands made upon them, and it is reasonable to suppose that normal engineering development will not outpace lubrication. Of course, new inventions are always liable to cause economic disturbances of some sort, but it is not long before equilibrium is restored. The hypoid gear created consternation when it was invented, but the chemist was soon on the trail with extreme-pressure lubricants. More recently, the jet engine has taxed the mind of the engineer as well as the chemist, but not in vain. The more complex a machine becomes the greater must be the precision of its components if the whole is to run in perfect harmony. Obviously, the lubrication must be as perfect as the structure.

Substances which are in universal and urgent demand are likely to be the subject of detailed scientific examination, so long as attention is focused on their economical production and use. It is not surprising, therefore, that in Great Britain and the U.S. a study of lubrication has been eagerly pursued. The progress which has been made has brought us to the state at which any new lubricant must show early promise if it is to succeed. Grease, however, has not received the attention which it must now receive.

In my Presidential Address last year * I stated that the original term " grease " was usually restricted to those soft fats in the tissues of animals, which are solid or nearly so at temperatures not greatly exceeding that of the living animal. So, when soap greases became articles of commerce, they were called " hard greases."

In those days grease was made from tallow or palm oil rendered alkaline with soda or lime water. Soon it became a product made from every available fat, oil, wax, asphalt, rubber, cork, asbestos, ivory dust, hair, or sawdust. Grease was just grease. But, by 1880, grease was made of tallow, sodium or potassium soap, and a minor quantity of mineral oil. Twenty years later it became mineral oil to which calcium or sodium soaps were added. Calcium soaps were used more frequently than the sodium soaps. Then, with the introduction of rosin acids, grease became rosin thickened with lime, or less frequently litharge and mineral oil. These greases often contained 20 per cent of water and a little sawdust to stop gear rattle.

Such greases having so little hope of attaining glory or admiration, it was sufficient to have an approximate idea of their rheological properties, so the consistency test of Legler [1] was introduced. The consistometer was a pointed glass rod fitted with a scale pan, and supported by a spring. Weights were applied until the rod penetrated the grease to a depth of 1 cm.

Later came the drop point first suggested by Pohl. It was the temperature at which a smear of grease on the bulb of a thermometer started to flow or drop off. When Ubbelohde re-designed the test, he enclosed the grease in a small glass cup with a hole in the bottom through which the

* *J. Inst. Petrol.*, 1949, **35**, 379–90.

grease could flow when it reached a particular temperature.[2] In 1909, Gillett [3] adopted a modification of the well-established capillary-tube method used for melting-point determinations. He inserted a glass tube 0·4 cm internal diameter, and 8 cm long, into the grease, so that a plug of grease 1 cm long was left in the tube. The tube was then immersed in water and heated. When the grease began to rise the temperature was noted as the melting point.

The Standardization Committee of the Institute chose the Ubbelohde apparatus for consideration, and after standardizing its dimensions, adopted it as a standard test in 1935.

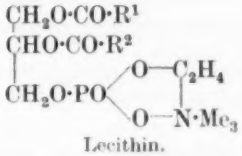
The large quantity of water which was present in the greases led Marcusson [4] to suggest a quantitative estimation by boiling the grease with xylene to expel the water, which can be condensed and measured. The Dean and Stark method is a variation of the Marcusson method.

The greases of bygone days were used only for unimportant forms of lubrication. But, when Stribeck and Hertz, at the Ammunition Factory, Berlin, gave an impetus to ball-bearing design, a demand for a better grease arose. Ball bearings give rolling friction against sliding friction in plain bearings. Hertz, however, showed that compression of the ball takes place, and that point contact is expanded into a measurable area over which sliding occurs.

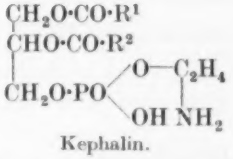
Fortunately, the balls rotate about two axes; consequently, there is constant change of surface. The spinning effect may be of the order of one revolution in one direction and six hundred in another. The precision of such bearings made it necessary to exclude abrasive matter and influences likely to lead to rust. A wall of grease is an effective barrier against dirt intrusion and a protection against rust. As speeds and loads increased and designs varied grease-making improved.

But, just as the bubble of improvement was swelling nicely it was pricked by the shortage of fats in the second world war. The grease-maker, deprived of some of his favourite materials, had to turn with rapidity, under the stress of war, to readily available material. Fortunately, recovered grease from the wool-washing areas proved to be a satisfactory raw material for grease-making. The shortage of fats and the variety of fats has deflected attention to a more serious inquiry into grease production. At the present time scientific research is growing in intensity.

The fats from which greases are made are combinations of fatty acid with a trihydric alcohol, glycerol; waxes are fatty acids combined with a monohydric alcohol, of which cetyl alcohol is an example. Natural fats also contain phosphatides consisting of fatty acids, glycerol, and a nitrogenous base



Lecithin.



Kephalin.

Although the number of fatty acids found in Nature is considerable, the number existing in any one fat is very few.

The fatty acids are straight chain, monocarboxylic, and mainly lie within the range of 12 to 20 carbon atoms. Some are saturated, and some unsaturated.

Stearic	$CH_3(CH_2)_{16}\cdot COOH$
Oleic	$CH_3(CH_2)_7CH{=}CH(CH_2)_7\cdot COOH$
Linoleic	$CH_3\cdot(CH_2)_4CH{=}CH\cdot CH_2\cdot CH{=}CH(CH_2)_7\cdot COOH$
Linolenic	$CH_3\cdot CH_2\cdot CH{=}CH\cdot CH_2\cdot CH{=}CH\cdot CH_2\cdot CH{=}CH(CH_2)_7\cdot COOH$

An approximate separation of the solid or saturated fatty acids can be made from liquid or unsaturated acids by saponifying, separating the acids, converting them into their lead salts, and fractionating with ether.

In general, the saturated acids are mainly found in animal fats, and unsaturated acids in vegetable oils. The division is not clear-cut, as palmitic acid exists in quantity in palm oil, and lauric acid in kernel fats. Marine oils are largely unsaturated.

In addition to the glycerides, fats contain unsaponifiable matter. Coconut contains 0·2 to 0·4 per cent, olive up to 1·5 per cent, whale up to 4 per cent, and wool grease up to 50 per cent. Some oils contain almost 100 per cent of an unsaturated terpene hydrocarbon, squalene, $C_{30}H_{50}$. Cholesterol $C_{47}H_{45}\cdot OH$, occurs as an ester in wool grease.

Although solid or semi-solid fats come from warm-blooded animals, the melting point of the fat is lowered as the position from which the fat is obtained approaches the skin, the extreme case being fluid neatsfoot, which is obtained from the feet. No such variation, however, occurs in human beings or hens. Whether this can be attributed to clothing or feathers is not known. The experiment of covering a pig with a fur coat to provide it with warmth did not alter the melting point of its fats. Diet and locality can influence the properties of fats, for example, pigs fed with whale oil produce a fat which quickly goes rancid.

Refined fats are almost sterile, but if they are not stored suitably they can go rancid through the presence of bacteria and moulds. Moisture is particularly liable to promote the growth of organisms. The disadvantage of rancidity, apart from colour and odour, is that the organisms attack the fatty acids by β-oxidation, in which they lose two carbon atoms at each successive stage and so lead to the formation of lower fatty acids.

$$R\cdot CH_2\cdot CH_2\cdot COOH \longrightarrow R\cdot CO\cdot CH_2\cdot COOH$$
$$R\cdot CO\cdot CH_2\cdot COOH \longrightarrow R\cdot COOH$$

Saturated acids are very stable (Fig. 1); in fact, they have withstood the conditions in Egyptian tombs for several thousand years, but unsaturated acids are prone to oxidation. The presence of a hydroxyl group in the ricinoleic acid accounts for its greater resistance to oxidation.

Ricinoleic acid $CH_3(CH_2)_5\cdot CHOH\cdot CH_2\cdot CH{=}CH(CH_2)_7\cdot COOH$

Elaidic acid, which is the *trans*-modification of oleic acid, is many times more resistant than oleic acid, due to the better screening of the ethylene linkage

$HC(CH_2)_7\cdot CH_3$	$CH_3(CH_2)_7CH$
$\|\|$	$\|\|$
$HC(CH_2)_7\cdot COOH$	$HC(CH_2)_7\cdot COOH$
cis-oleic.	*trans*-oleic or elaidic.

The position of the double bond is likewise important. When it is at the remote end of the molecule it is less easily attacked.

This very brief survey of fats is necessary to comprehend the story of grease. There is nothing new in it. It can all be found in the literature. Every one of the fatty acids found in Nature is a potential raw material for grease.

Grease is a mixture of soap and mineral oil. The soap is made either from fats or fatty acids obtained from fats, consequently, the number of acids which enter into the composition of the soaps is limited to a few. The grease-maker knows how to make grease from fats and commercial fatty acids, but there appears to be little information available about the making of grease from pure acids and the effect of mixtures of fatty acids in known proportions. The reason may be that pure acids are difficult to separate, and commercial acids are far from pure.

It must not be imagined that all soaps will form grease. Lawrence [6]

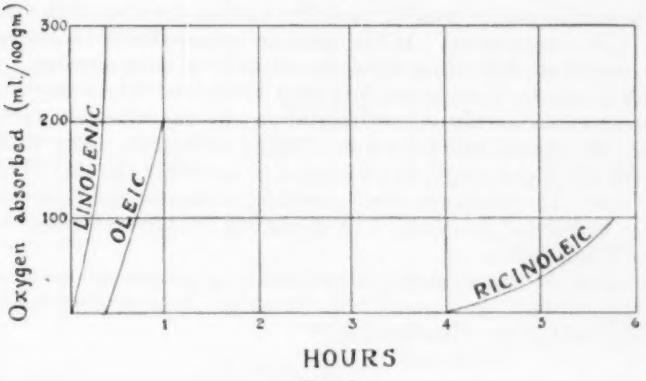


FIG. 1.

RELATIVE RATES OF OXIDATION OF UNSATURATED FATTY ACIDS AT 95° C.[5]

stated that soaps are very peculiar things. One of their still unexplained properties is that with oil they form grease. He believed [7] that only those soaps which do not melt sharply to isotropic liquids gelate in oil. Earle [8] was, however, inclined to place limitations on this suggestion. The difficulty about grease-making is that most soaps are insoluble in oil, but when they are heated with oil they pass through physical changes until finally they melt and dissolve in the oil. On cooling they pass through the same phases and the soap comes out of solution. Pure calcium stearate segregates from oil suddenly at 119° C.

There seems to be some evidence [9] that a physical change occurs in sodium stearate at 70° C, as indicated by a small change in specific volume, specific heat, and dielectric constant. Thermal energy is playing its first part in loosening the lattice. Between 125° and 130° C another change in the mesomorphic state occurs. At 125° C, it suddenly becomes plastic. At this temperature the hydrocarbon chains attain a maximum of freedom of motion in two dimensions, but the soap is still held together by the polar bonds of the soap. At 240° C it melts with complete disruption of the

polar bonds in the lattice. When considering the initial change which occurs at 70° C it is interesting to remember that stearic acid melts at 70° C.

Most greases are made at a temperature below the melting point of the soap, but above the transition point from plastic to gel state. Lawrence believes that when soap is heated with oil the lattice opens and oil enters. He also believes that, on cooling, sodium and aluminium soaps crystallize into very small crystals, giving the grease a paste-like structure. Therefore, if there are insufficient crystals, oil will separate. The crystals may be colloidal in size in any of the three dimensions. Calcium soap forms a gel which is approaching an homogeneous elastic system.

As it is frequently stated that grease is a colloidal solution, it may be useful at this stage to re-state that a colloid is a particle 1 μ — 1 mμ in size. It should not be regarded as a special group of substances, but rather as a group with defined dimensions. They are characterized by high ratio of surface to mass, which accounts very largely for their properties.

Sodium-soap grease is usually made by heating the soap with a mineral oil to a high temperature. If the mass is cooled rapidly a gel or solid block is obtained, depending upon the amount of soap present. In the cold block is a mass of tiny crystals of soap which hold the oil mechanically. If the mass is cooled slowly and with agitation a fibrous structure is obtained, due to the fine fibrils building up into bigger structures. Any method of pulling out the fibres serves to parallelize or orientate the fine fibrils into a larger fibre. The process is akin to combing cotton fibres into a condition which can be twisted into yarn. Even passing the grease through a capillary has a similar effect.

It should not be imagined that all sodium-soap greases can be orientated in this way, nor that they are all fibre forming. Sodium soap made from pure stearic acid is non-fibre forming [10]

Non-fibre forming	Ca—mixed fats
	Ca—mixed fatty acids
	Na—stearic acid
	Al—stearic acid
Fibre forming	Na—mixed fats.

From this observation it appears that glycerol and/or unsaturated acids are necessary to make sodium soap fibre forming.

Calcium grease, whether made from mixed fats or mixed fatty acids, has a smooth texture, due no doubt to the high degree of dispersion of the soap crystals and extremely short fibres.

To make a good sodium grease it must be heated until a partial disruption of the soap molecule occurs and then cooled sufficiently slowly for recrystallization of the soap. In the absence of glycerol there seems to be some evidence that mineral oil does not wet the soap, consequently, short fibres are obtained. In the presence of glycerol the soap is dispersed at a lower temperature, and longer fibres result. The length of the fibre is dependent upon the quantity of glycerol present.

A grease-maker knows that if he wishes to increase the fibre he introduces rape oil into his mix. But does he realize that its true purpose is to introduce an unsaturated acid? An unsaturated acid has a marked effect upon lengthening fibre.

Mineral oil also can exercise an important part in fibre length. When sodium stearate is thoroughly dispersed in mineral oil and heated, swelling occurs. The swelling temperature depends upon the oil used (Table I).

TABLE I.

Soap.	Visc, sec.	Oil, V.I.	Swelling temp, ° C.
Na stearate . . .	300	95	125
	300	70	120
	300	40	120
	1200	−95	120
Na oleate . . .	300	95	105
	300	70	90
	300	40	75
	1200	−95	60–65

Whatever may be the viscosity or the V.I. of the mineral oil, it does not affect the swelling temperature of the sodium stearate. But a change of V.I. has a marked effect upon sodium oleate.

Now consider the effect of V.I. upon fibre length (Table II) :—

TABLE II.

Soap.	Oil.	Fibre length.
Oils of same visc (500 sec), varying V.I. :	V.I.	
Na stearate	95	Very short
	70	Little longer
	40	Still longer
50% Na stearate, 50% Na oleate	95	Fairly long
	70	Longer
	40	Very much longer
Oils of same V.I. (95), varying viscosity :	Visc sec.	
Na stearate	500	Very short
	300	Very short
	100	Longer
50% Na stearate, 50% Na oleate .	500	Fairly long
	300	Longer
	100	Still longer
Oils of low (40) V.I. and 100 sec visc :		
50% Na stearate, 50% Na oleate .	100	Very long
Na oleate	100	Longest

The fibre length of sodium stearate is very little affected either by changes in V.I. or viscosity, whereas sodium oleate is affected by both.

Sodium stearate in a 95 V.I. oil shows very little increase in viscosity even when heated to 205° C, and on cooling produces no fibres. With a 40 V.I. there is a sudden increase in viscosity at 160° C. When the heating is continued to 205° C, and cooled, fibres of moderate length are formed. But when glycerol is present even with the stearate long fibres are produced.

Should it be necessary to produce extra long fibres the addition of phenol is often useful. Resorcinol shortens the fibre, and hydroquinone destroys

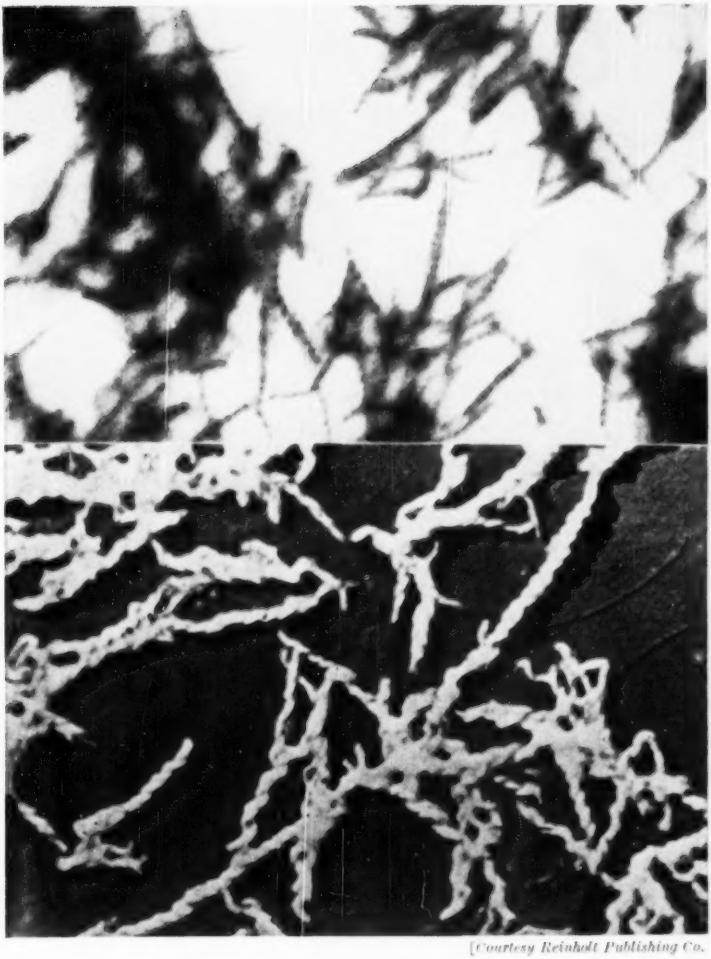
it. This is important to those who might be contemplating adding a phenolic antoxidant. The action of phenols on aluminium stearate varies considerably in low-boiling-point petroleum spirits.[11] *o*-Cresol, 2 : 4- and 2 : 5-xylenols are weak peptizing agents, whilst phenol is powerful. In general, there is a decrease with each additional methyl group. Further, if the methyl group is in the *ortho*-position to the hydroxyl group it has the greatest influence in reducing the peptizing power of the phenol. Dihydroxyphenols and pyrogallol have a marked peptizing action. The power increases with the number and proximity of the hydroxyl groups.

Most greases require a peptizer to stabilize them, very much in the same way that emulsions require a third substance to stabilize them. Greases, however, are not emulsions; they are definitely solid soaps dispersed by peptizers in oil. The common peptizers are water, glycerol, fatty acid, but there are many more from which a selection can be made for specific reasons. For calcium grease, wool-fat alcohols, glycerol monostearate, triethanolanine, and glycols are suitable. These, in addition to castor oil and β-naphthol, can be used with aluminium grease. It is claimed that aluminium stearate will stabilize calcium grease, but there is the possibility that the responsibility belongs to the free stearic acid which is usually attached to it. The use of too much peptizer may result in liquefaction of a grease.

The effect of fatty acids is not uniform.[12] In small amounts oleic acid prevents gelation of sodium oleate in pinene, but when the quantity is increased the system sets to a firm transparent gel which does not synerize. With stearic acid the system does not set to a gel even when the acid content is varied over a wide range. Small quantities of palmitic acid retard syneresis, and if the amounts are increased the system gives a loose, viscous mass instead of a rigid gel. Benzene and toluene retard, while xylene and mesitylene accelerate syneresis. There appears to be a relationship between the number of methylene groups and the retardation or acceleration of syneresis.

Even soaps have effects upon other soaps.[13] Soaps in admixture affect syneresis. Of course, it has long been known that calcium and sodium soaps will soften an aluminium grease.

With the advent of the electron microscope (Fig. 2) fresh revelations have been made.[14] Confirmation has been found that a stabilizer must be present in calcium grease. If it is water, the calcium-soap fibres twist into a rope-like structure. When the water is expelled it untwists and finally loses its structure. To ensure a twist there must be 1·3 per cent of water. When the water content falls to 1·1 per cent untwisting commences, and when it reaches 0·4 per cent all the structure has disappeared. If water is added to the dehydrated grease, twisting recurs, and if the water content is increased to 2·4 per cent the fibres lengthen, but do not widen. The fibres can be torn apart by working. What causes the twist is not known, although stirring may be a contributory factor. Perhaps one could postulate that the work on the structure of fibres at Leeds University will assist in elucidating such interesting yet difficult problems. It has been shown that calcium acetate converts the amorphous dry soap into fibres, but they are not twisted. It seems to assemble the fibres into bundles. For effective structural stabilization, calcium acetate and water must be



[*Courtesy Reinhold Publishing Co.*

FIG. 2.

TOP: ORDINARY ELECTRON MICROSCOPE PICTURE OF A CALCIUM STEARATE GREASE (× 20,000).

BELOW: SHADOW ELECTRON MICROGRAPH OF SAMPLE OF A SIMILAR GREASE (× 35,000); SHADOWS ARE CAST BY CHROMIUM MOLECULES.

(From "The Electron Microscope", Burton, 1946).

[*To face p.* 374.

FIG. 3.

present in molar concentrations approximately equal to or greater than that of the soap. When fibre disintegration occurs, syneresis follows. Since this work was published, evidence has been collected from X-ray-diffraction patterns that anhydrous calcium stearate can exist in three different structures depending upon the rate of dehydration.[15]

The electron microscope has also revealed that the fibres of sodium laurate (Fig. 3) are not only interwoven, but actually grown together.[16] The fibre junctions give rise to many capillary spaces in which water or oil can be retained. The characteristically curved formation of sodium laurate is not common for all sodium soaps, as sodium palmitate is generally straight. The fibres of soaps are built-up structures of soap molecules in double rows with the carboxylate groups together (Fig. 4).

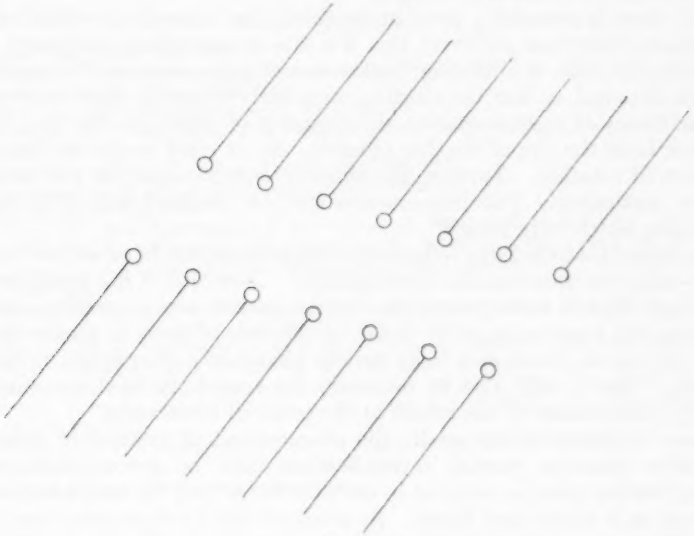


FIG. 4.

The molecules, however, are not long, thin things with a long hydrocarbon chain attached to a carboxylate group. Sodium laurate is only three times as long as it is broad, and sodium stearate has a length five times its width.

For many years there has been controversy about the stability of aluminium grease and the existence of mono-, di-, and tri-aluminium soaps. The objective is to prepare the soap which gives the greatest stability in oil. Some aluminium greases are particularly prone to liquefy on ageing. It is claimed by some observers that the di-soap produces the most satisfactory grease, therefore a satisfactory method for making it is welcome.[17] If potassium soap is added to a large excess of an aqueous solution of aluminium chloride the di-soap is produced, but it is usually associated with 20 to 30 per cent of free or loosely attached fatty acid which is extractable with anhydrous solvents, leaving the di-soap. If the precipitation of the laurate soap is done at 25 to 30° C free floating flocs of aluminium dilaurate are

formed which are easily washed. When the temperature exceeds 40° C a sticky soap is formed which on cooling sets to a hard, brittle mass, though both appear to be the same chemically and both melt at 195° to 197° C. Whereas the distearate forms a slow filtering mass when precipitated at 50° to 60° C, when precipitated at a high temperature it is a fine powder. Whether the subject has really been finalized it is difficult to say.[18]

An aluminium salt which has a remarkable thermal stability is aluminium di*cyclo*hexane carboxylate, $Al(OH)(C_6H_{11}COO)_2$. It melts at 450° C with decomposition.

The structure of aluminium stearate is not known, but opinions have been expressed that it is a polymer bound by weak intermolecular links,[19] which may harmonize with the fact that aluminium grease can lose consistency when fed from a grease-gun.

That there is something peculiar to aluminium stearate is exhibited by the curious behaviour observed, that if a disc is maintained stationary and parallel to the base of a rotating beaker containing a solution of aluminium stearate in petrol, so that the solution completely covers the disc, there is an upward thrust at right angles to the direction of rotation, and that there is a flow from the rim of the disc inwards, also at right angles to the main direction of rotation. Further, the solution tends to climb the rod holding the disc stationary. This phenomenon was not observed with other types of colloids which were tried.[20]

It is hoped that the facts collected in this address will be of service to the grease-maker in directing his investigations. Now that it has been proved that soaps exist in more phases than liquid, plastic, and crystalline, added attention will have to be given to the significance of them in grease operation. It may be found that these several phases owe their origin to traces of water. But it will also be necessary for somebody to determine the working temperature of the grease at the point of lubrication.

Grease formation is essentially the phenomenon of gelation of soaps in oil. After gelation, partial crystallization may be accompanied with cooling, but the gelation seems to be essential for getting the soap adequately dispersed as a thickening agent. At some elevated temperature the soap passes from a gel into a true solution and ceases to thicken it usefully, whereas at a lower temperature segregation of the soap occurs. The conventional method of preventing the syneresis has been the addition of small amounts of water or glycerol without understanding the nature of the process. This peptization of the soap by these means stabilizes at normal temperatures, but unfortunately lowers the gelation temperature, thereby restricting the operational-temperature range.

By a greater discrimination of the fatty acids used it is possible to widen the temperature range of the gel state. The effect of the metalkation of one soap on another soap has received some attention. Although the commercial possibilities have not yet been established, the mixing of kations is promising. Provided the soap has a high enough gelation temperature, peptizing agents containing a polar group have the greatest appeal in spite of their chemical activity and liability to encourage corrosion.

That controlled syneresis should occur is held by some to be essential to efficient lubrication, whilst by others that syneresis should not occur. In

fact, a test has been introduced which implies that a calcium grease shall be virtually free from syneresis at a temperature higher than that at which dehydration occurs, or that temperature at which structural changes take place. From this it will be apparent that a fundamental research is necessary to establish whether lubrication is due to free oil or grease. Obviously, uncontrolled oil separation is undesirable.

The importance of physical tests will not be denied, nor can one underestimate the need for mechanical tests, but until the scientific build-up of grease has been more perfected there is the possibility of using bench tests like bromides as a substitute for action. Many of the short-range twists and turns have been born of expediency. It is now time that the mixture of interests should combine together into a compound.

References.

[1] *Chem. Ztg*, 1884, viii, 1657.
[2] Holde. "Untersuchung der Mineralole und Fette 1905," p. 209.
[3] *Industr. Engng Chem.*, 1909, 351.
[4] Mitt, K. *Materialsprufungsamt*, 1904, **24**, 48.
[5] Holm, G. E., Greenbank, G. R., and Deysher, E. F. *Industr. Engng Chem.*, 1927, **19**, 156.
[6] Lawrence, A. S. C. *J. Inst. Petrol.*, 1945, **31**, 303.
[7] Lawrence, A. S. C. *J. Inst. Petrol. Tech.*, 1938, **24**, 207.
[8] U.S.P. 2,274,673, 1944.
[9] Gallay, W., and Puddington, I. E. *Canad. J. Res.*, 1943, **21**, 202.
[10] Gallay, W., Puddington, I. E., and Tapp, P. *Canad. J. Res.*, 1944, **22**, 66.
[11] Cawley, C. M., Carlile, J. H. G., King, J. G., and Kingman, F. E. T. *J. Inst. Petrol.*, 1947, **33**, 649.
[12] Prasad, Hattiangdi, and Adarkar. *Proc. Indian Acad. Sci.*, 1945, **22**, A. 320.
[13] Hattiangdi. *J. Sci. Ind. Res. India*, 1946, **4**, 489.
[14] Birdsall, D. H., and Farrington, B. B. *J. phys & colloid Chem.*, 1948, **52**, 1415.
[15] Vold, Hattiangdi, and Vold. *J. Coll. Sci.*, 1949, **4**, 93.
[16] Marton, L., McBain, J. W., and Vold, R. D. *J. Amer. chem. Soc.*, 1941, **63**, 1990.
[17] Smith, Pomeroy, H. H., McGee, C. G., and Mysels, K. J. *J. Amer. chem. Soc.*, 1948, **70**, 1053.
[18] Gallay, W., and Puddington, I. E. *Canad. J. Res.*, 1948, **26**B, 155.
[19] Sheffer, H. *Canad. J. Res.*, 1948, **26**B, 481.
[20] Nissan, A. H. Private communication.

Induction of New President.

Mr E. A. Evans: For the past two years it has been my privilege to gaze upon the portraits in the Council Room of those renowned presidents who have preceded me in the steady march of progress. Now, the time has come for me to resign myself once again to the sweet days of ease and simplicity, but before I vacate this chair, it is my very pleasant task to install Mr C. A. P. Southwell into the presidential chair.

The Institute of Petroleum covers, through its Corporate Members and Branches, the complete range of the industry's activities from petroleum surveys, through geology and geophysics, drilling and production, to refining and processing, and even to distribution and marketing. It is therefore very appropriate that our selection of president should not be confined to one phase of the industry, but should throughout the years cover all aspects.

Mr Southwell has had thirty years' experience in the petroleum industry, the larger part of which has been with the Anglo-Iranian Oil Company. His very wide knowledge has been mainly directed to the problems asso-

ciated with the supply of crude petroleum, the raw material without which there would be no petroleum industry. It is probably true to say that he has seen with his own eyes as much of the activities of our industry throughout the world as anyone. His very extensive travels have brought him into close contact with the activities in Texas and California, in Trinidad and Eastern Venezuela, in Persia and Iraq, and even Australia and New Guinea.

Not only is he known as a traveller, but also as a speaker, in which capacity he has addressed meetings as far apart as Chicago, Trinidad, and Australia, and of course our own Institute in London and its Branches in Britain and overseas.

Recently, he has had a very important part to play in the outstanding developments in the Arab State of Kuwait, in the Persian Gulf, where in the space of a mere three years, there has been developed what is now the largest single producing oilfield in the world. It has recently even exceeded the output of the East Texan field of our American friends.

During the war, Mr Southwell was very actively connected with the oilfields in Nottinghamshire, which played a modest though important part in our war requirements. I believe that it is correct to say that these oilfields were the smallest ever to have been found by scientific means—which of course implies geophysical methods—and to have been scientifically operated from the inception. Our new president may therefore claim to range his experience from the smallest to the largest.

As Petroleum Technologist to the Government of Trinidad, he was able to give wide range to his ability in an area where the technical problems of oil recovery are well known to be difficult.

Mr Southwell was one of the earliest students of one of our Past Presidents, Lord Cadman, when he was Professor in the School of Petroleum Engineering at Birmingham University; consequently Mr Southwell must feel very proud to be able to occupy a position which his former chief previously held.

A man who has lived a life so rich in experience and achievement, and yet has maintained a great sympathy and understanding in human affairs, is obviously very well qualified for the special trust which the office of president implies—an office with an immense capital of prestige.

It gives me very great pleasure to wish Mr Southwell much happiness in his term of office as President of the Institute of Petroleum.

Mr C. A. P. Southwell: At the commencement of my year of office I wish to take the very first opportunity I have of expressing to everyone in the Institute my full realization of the very great honour which the Council and members of the Institute have conferred upon me in electing me to the presidential chair.

It is my earnest hope that I may be able to fulfil the duties of the position with satisfaction to you all, and I trust with some benefit to the Institute.

I particularly wish to thank Mr Evans, who has maintained the very high standard set by his predecessors and undertaken his duties with such distinction during the last two years—two years of hard endeavour—and we are all glad to see he has completed it without apparent detriment to his health. I want to thank you, Sir, for the eulogistic observations concerning myself and for the kind way in which you have inducted me into the chair.

We have just had the pleasure of listening to Mr Evans' presidential

address, but as it is not our custom to discuss a presidential address, I would like to thank him for covering a subject which is not often dealt with at our deliberations. We will have pleasure in studying it at our leisure in the *Journal*.

As Mr Evans has remarked, I have been given opportunities of working in and visiting a good many widely separated places where oil is won, and whilst it is not customary for a newly installed President to give a lengthy address at this time, I should like to leave two thoughts with you to-night.

I should like to draw attention to the fact that air travel is causing a change in oil-company administration, and with the speed of jets an even greater change will come about which will have a direct bearing on the future activities of the Institute.

Our industry is of a global nature, and whereas in the past men have proceeded overseas for a number of years without returning to this country, there is coming about a position where our members return to headquarters either for consultation or for leave at much more frequent intervals. This means the presence in London of many more of our members from abroad for short periods, members whose knowledge and experience we must take advantage of whilst they are here, for the good, particularly, of our younger members and also for those of us who are at the other end of the scale.

No industry has a finer selection of men covering as they do so many of the technical and scientific problems of our present-day world; men who are broad-minded and always willing to help their fellow men by an exchange of knowledge and experience.

Recent improvements in speed of air travel require us to take the fullest advantage of this situation. It is, I feel, a challenge to the President and Council to see that we do not miss the advantages that are to be had by all by an interchange of ideas with men from overseas.

Air travel is now presenting us with many opportunities to take advantage of the presence in Britain of our American colleagues. I can think of nothing better for the Institute to do than to ensure that it plays a real part in providing the opportunity for contact, discussion, and friendship between British and American friends in our industry, a friendship so essential in world affairs.

The British leaders of our industry have played a great part in the development of the world's oil resources and also in the scientific field, which is hardly yet tapped, of processing the sometimes unruly hydrocarbons, and our Institute should have a branch in every part of the world where oil is won or processed and where Britishers are employed.

I should like to take this opportunity of mentioning the Second Oil Shale and Cannel Coal Conference which is to be held in Glasgow this coming July. It is, as you all know, the centenary of that very famous Scot, James Young, who 100 years ago was granted a patent for the production of oil from shale, cannel, and similar materials. It is interesting to note that in the first Presidential Address to the Institute in March 1914, it was remarked that the first aim of the Institute was to enable technologists engaged in the petroleum and shale-oil industry to meet, and I hope that this historic occasion will be well supported and that our friends in the Scottish Branch will have the success that they deserve.

When I was approached to see if I would be prepared to accept this high office of president, I hesitated very much, but I hope that with the blessing of my principals, and with the assistance of past-presidents, council, and members, I shall justify the confidence you have placed in me.

Vote of Thanks to Retiring President.

Mr C. A. P. Southwell : I will now call on Mr Dewhurst to propose a vote of thanks to Mr Evans, which will be seconded by Colonel Auld.

Mr T. Dewhurst : It gives me great pleasure to propose a vote of thanks to the retiring president. He is, as you all know, an acknowledged authority on lubricants and lubrication, and has done very much to foster co-operation in petroleum and automobile research.

The very interesting and valuable address to which we had just listened will be very widely read and thoroughly appreciated wherever the *Journal* is circulated.

Two years ago Mr Evans voluntarily undertook the onerous duties and responsibilities of President, and by a rare blend of courtesy and consideration, fairness, humour, and common sense, he enjoyed the respect and goodwill of all his colleagues. During his term of office there has been continued expansion of the activities of the Institute, but enlarged accommodation, increased rent, and higher printing and administration costs presented a formidable financial problem which fortunately has been satisfactorily solved during his term of office.

At our ordinary, special, and annual meetings and at the more imposing public functions Mr Evans has proved to be an eloquent and dignified figurehead.

His visits and addresses to the branches have effected a closer integration of the activities of the Institute, while on his official visits overseas, notably to the U.S. and to France, he has proved to be an admirable ambassador and has knit more closely the ties which bind us to our kindred institutions in other countries.

In all those activities he has worthily upheld the traditions and prestige of his office, and therefore it is with pleasure and confidence that I invite you to accord the hearty vote of thanks which Mr Evans has richly earned by his services.

Col S. J. M. Auld, seconding the vote of thanks, said : It is a special and intimate pleasure to me to second this vote of thanks. A special pleasure because it is not every day that one gets a chance of saying to a friend " Well done ! ", and intimate because I have known and admired Mr Evans personally for a great many years as a professional associate, a very friendly business rival, and a wartime colleague. Under those conditions one gets to know a man as he really is and can appraise his worth.

Mr Evans is himself by way of being a philosopher, and he will realize as a lot of us do, that the sweetest reward that comes for our labours is that of the praise of one's own family. It is the praise of our own family and peers that counts most : it is praise from the people who know that is the really satisfying honour, and it is in that sense that I want Mr Evans to appreciate the vote of thanks as a recognition by us of his great value and of the work that he has done.

It is rather typical of him, I think, that, in his versatility in research and

technology, he has in that fine address which he has given us added to the fields which we know he has already conquered. We know his reputation, which he has built up in the field of lubrication and has achieved both for himself and his colleagues, and which has added such credit to the Institute of Petroleum and indeed, to Britain as a whole. I am thinking particularly of the work that Mr Evans has done in the development and synthesis of special chemical additives for increasing the load-carrying capacity of mineral oils. But there are many other patents and papers with which many of us are acquainted and which add lustre to his career and reputation in that field.

As Mr Dewhurst has said, Mr Evans has invariably carried the position of president of the Institute of Petroleum with great dignity and purpose both at home and abroad and I feel it an honour to be allowed to join with Mr Dewhurst in proposing that vote of thanks which I am sure represents the wishes of the whole Institute.

MR EVANS, in response, said: I feel very touched indeed by the kind words which have been so carefully chosen by my very good friends of many years; Mr Dewhurst and Col Auld. I have a great affection for those two men. They have, as you know, served the Institute for many years and we look up to their guidance.

I have enjoyed very much indeed those two years. I will not say they got me new friends, but they have cemented friendships which existed. I have met many new people in many parts of the world, and I feel that the Institute is now at a very high level and is something of which you could be proud. I think the annual dinner was a manifestation of the strength of the Institute. If I have been able to serve you I have been very pleased. To me it has been a great duty. I thank you.

This concluded the meeting.

GAS LIFTING OIL IN THE TURNER VALLEY FIELD.

By S. F. Shaw.

The oil zone of the Turner Valley field, Canada, was discovered in June 1936 in the Madison Limestone at depth of 6828 ft, and since that time approximately 300 productive oil wells have been drilled, covering an area of about 15,000 acres. At the end of 1949 there were about 280 producing wells in the field, the deepest of which reached a depth of 10,237 ft. Spacing has been on 40-acre basis, with the exception of a few wells drilled on 20-acre spacing. Porosity is not uniform, and has been variously estimated at 7 to 12 per cent, with a combined thickness in the two productive zones of about 165 to 180 ft. So far as the author knows, no actual determinations of porosity have been made in this field. The gravity of the oil at the time of discovery was 52° A.P.I. in the shallower wells adjoining the gas cap, and about 41° A.P.I. in wells lowest on the flank of the structure. The usual casing employed was 7-in O.D., with a few strings of 6⅝-in O.D. As a general practice, tubing has been 3-in I.D., although a few tubing strings of 2½-in and 2-in I.D. have been employed.

In the early life of the wells the gas that was produced with the oil provided several times as much energy as was necessary to propel or carry the oil through the formation to the well and then to lift it to the surface. During this period there was not sufficient demand to permit extraction from wells at maximum capacity, especially during the winter months, and it was then necessary to restrict severely the withdrawal rate. During the summer months the wells were produced at considerably higher rates, and it was observed during the summer months that the gas–oil ratios increased markedly and then decreased quite considerably when production was restricted during the winter months. There has, however, been a gradual increase in the yearly average gas–oil ratio even though the production has been restricted, and it raises the question whether the oil which was of necessity not produced during the winter months would have been produced with a cumulative average gas–oil ratio as low or lower than it has been over the past fourteen years. Gas–oil ratios in yearly periods for the limestone reservoir oil production are given in Table I.

It must be recognized that when oil or gas is produced from a reservoir, the pressure in the reservoir is gradually reduced unless some other fluid is injected into the reservoir to take the place of the withdrawals. If the oil is saturated with gas, some of the gas dissolved in the remaining oil comes out of solution as the pressure declines. A portion of this gas accompanies the oil that is produced, and some migrates to the upper part of the structure, where it forms a gas-cap condition. This action results in gas–oil ratios that gradually increase throughout the reservoir, such as has been the case at Turner Valley, particularly in wells in the upper part of the structure which are affected by the gas-cap condition.

TABLE I.

Year.	Barrels of oil produced.		Million cu. ft. of gas.	Gas–oil ratios.	
	Year.	Cumulative.		Year.	Cumulative.
1936	671,948	671,948	4,151	6,200	6,200
1937	2,098,970	2,770,918	16,546	5,900	6,000
1938	6,150,512	8,921,430	41,778	4,100	4,700
1939	7,251,063	16,172,493	65,326	3,300	4,000
1940	8,173,016	24,345,509	95,217	3,700	3,900
1941	9,531,207	33,876,716	116,839	2,300	3,400
1942	9,695,913	43,572,629	147,298	3,100	3,400
1943	8,986,663	52,559,292	175,148	3,100	3,300
1944	7,874,917	60,434,211	205,096	3,800	3,400
1945	7,005,589	67,439,800	236,544	4,500	3,500
1946	5,928,444	73,368,244	268,077	5,300	3,600
1947	5,917,292	78,385,538	299,491	6,360	3,800
1948	4,428,688	82,814,224	330,243	6,900	4,000

During the first three or four years of the field's operation, gas–oil ratios of 3000 cu. ft/brl were regarded as high, and yet it will be observed that after the year 1943 the gas–oil ratio has been climbing steadily above 3000 cu. ft/brl even though oil that was held back under restriction has had to be produced during these later years.

Early gas-lift tests were carried out in wells down the flank, at depths of 8222 ft and 8639 ft respectively, and showed that gas lift could be effective in lifting the oil when natural flow ceased to function satisfactorily. Gas-lift operations were not put into use at that time, however, since the wells were able to produce their allowable without recourse to artificial methods. Since 1941 the bottom-hole flowing pressures have declined steadily, and this, together with encroachment of small quantities of water, made it necessary to employ gas lift beginning with the year 1945. Since 1945 there has been a gradual move towards the installation of gas lift, particularly in the deeper wells, inasmuch as other lifting methods have not proved economically profitable or practicable. Some of the wells at shallower depths also have been put on gas lift, and the outlook for gas-lift application on other shallow wells appears promising.

The advance of edgewater has been slow, as would be expected in a formation with the low porosity and permeability found in this field, and as edgewater advances towards the wells, it is noted that gas–oil ratios gradually decrease because the water advancing does not carry in solution any appreciable quantity of gas. Encroachment of water which has to be lifted with the oil, coupled with the condition that the oil in these wells has to be lifted through a much greater distance than in wells up the dip, has brought about a gradually increasing need for artificial lifting methods in order to produce this oil.

Of late years, whenever for any reason extraction in a well has been restricted, it has become evident in wells on natural flow that the gas–oil ratio has increased, and whenever wells are produced at higher rates the gas–oil ratios have become reduced. This has not applied to all wells, particularly those close to the gas cap, but it has been so in the majority of wells. Therefore, it might seem that a greater ultimate recovery would

be obtained if wells showing this tendency towards lowered ratios would be produced at higher rates of extraction, while the wells showing the opposite trend would be produced at lower rates. From an administrative point of view, however, this procedure could easily cause difficulties.

It has become apparent that whatever was the position with regard to gas–oil ratios in the early life of the field, the situation now deserves further consideration inasmuch as the greatest ultimate recovery of future reserves depends primarily upon utilizing the gas associated with the oil to maximum advantage for moving the oil through the formation to the wells. Once the oil is delivered to the well bore, it can be lifted by artificial means.

When natural flow conditions prevail in a well, the function of the gas associated with the oil in the reservoir consists of two operations which are wholly distinct. These two operations are : (1) moving the oil to the well, and (2) lifting the oil to the surface. There comes a time in many fields when the quantity of gas required to lift the oil to the surface is greater than that required to move the oil through the reservoir to the well, due to the increased quantity of gas required to lift the oil through the greatly increased distance through which the oil must be lifted, and to the reduced pressure existing at the bottom of the well. When this time is reached, the minimum quantity of gas that will accompany a barrel of oil to the well should be supplemented by gas lift, so as to make it unnecessary for the oil to be accompanied from the reservoir by more gas than what is necessary to move the oil to the well bore. This excess gas is lost energy in the reservoir, and results in reducing the ultimate recovery.

Flowing pressures at the bottom of the wells are now down to values varying from 500 p.s.i. to as low as 80 p.s.i., which means that if wells are restricted to such an extent that it is necessary to impose a back pressure of 50 per cent of the flowing pressure in order to carry out this restriction, considerably more than 50 per cent of the lifting energy in the gas is wasted at the well-head. For instance, if the flowing pressure at the bottom of the well is 100 p.s.i. the foot-pounds of work inherent in a cubic foot of this gas at sea-level is about 4400, and if a back pressure be imposed at the well-head amounting to 50 p.s.i. the energy so wasted is about 3100 ft. lb. or about 70 per cent of the total expansive energy stored in the gas at the bottom of the well. It is therefore evident that it requires much more gas to lift a barrel of oil under such a condition of back pressure than if there be no back pressure imposed.[1]

The porosity in the producing formation of the Turner Valley field is so low that it is doubtful whether any form of secondary recovery method will be effective in this field. Therefore, it is important that the operator should extract as much oil as possible for every cubic foot of gas that is associated with the oil in the reservoir. The Royalite Oil Company deserves credit for experimenting with water injection in a well down the flank of the structure at the rate of about 1500 brl per day, to determine whether water flooding can be utilized. It is understood that during the past year of operation some benefit has been observed in one or two nearby wells, and further effort may determine whether this project is commercially feasible.

Gas-lift operations are now being carried out by the various companies,

[1] S. F. Shaw. *J. Inst. Petrol. Techn.*, 1932, **18**, 692–700.

some of which use or have under consideration the use of plunger-lift installations. Casing-head pressure has been reduced to 65 p.s.i. or about 80 p.s.i. at the bottom of the well in one plunger-lift operation while producing about 40 brl of oil per day from a well 8639 ft in depth through 2½-in tubing. However, freezing troubles as well as some other troubles have been encountered when using the plunger lift to a greater extent than when employing continuous gas-lift operations. However, bottom-hole pressure can never be reduced to as low a point on continuous gas lift as by means of the plunger lift.

It has been demonstrated even on natural flow with little back pressure that gas–oil ratios have been reduced. Some examples are given in Table II.

TABLE II.

Examples of Increased Production and Reduced Gas–Oil Ratios by Reducing Back Pressure in Turner Valley Wells.

Well.	Average production per month during six months preceding reduction of back pressure.		Average production per month during six months following reduction of back pressure.	
	Brl/month.	Gas–oil ratio.	Brl/month.	Gas–oil ratio.
Brown No. 2 . .	726	9,300	1,105	5,050
Three Point . .	826	6,800	1,353	4,600
Davies No. 1 . .	686	12,600	841	7,500
Davies No. 2 . .	266	20,000	351	17,100
Davies No. 2 . .	—	—	389	16,000 *

* During the next five months, after the first six months.

Some results of applying gas lift to wells in the Turner Valley field are given in Table III.

TABLE III.

Well.	Average brl/month.		Average gas–oil ratios.	
	Before applying gas lift.	After applying gas lift.	Before applying gas lift.	After applying gas lift.
Anglo No. 1 .	1,277	1,750	2,850	2,100
Anglo No. 5 .	838	1,130	2,100	3,560 *
Anglo No. 7 .	3,651	3,470 †	2,700	2,530
Extension No. 2 .	1,607	2,583	1,540 ‡	2,020
Four Star . .	2,598	3,558	1,660	1,180
Vulcan-Brown .	2,264	2,939	2,800	1,980
Davies No. 4 .	376	638 §	16,000	9,200

* This well is on plunger lift. The intermittent character of the flow makes the computation of output gas almost impossible to determine.

† Water percentage produced in this well has been 33·3 per cent for the first nine months of 1949. This well with Nos. 1 and 5 Anglo are the lowest wells on the structure in this vicinity.

‡ Extension No. 2 of the Anglo-Canadian Oil Co. was placed on gas lift in September 1945, and appears to have been the first well in the Turner Valley field to have made regular use of gas lift.

§ There has been only one month's report as yet on the operation of No. 4 Davies on gas lift, during which time no gas was returned to the upper porous zone, and was, therefore, a straight gas-lift operation.

Four Star No. 1 of the Brown-Moyer-Brown Co. was one of the early wells placed on gas lift in the Turner Valley field. In this well a packer was set between the two productive zones and a perforation was made in the tubing above the packer so as to admit sufficient gas from the casing into the tubing to lift the oil from the lower zone at maximum rate, depending upon the quantity of formation gas that the well was allowed to produce. Gas is injected into the casing for lifting the oil and also for injecting as much gas into the upper zone as this zone would take under the pressure which is practicable. Any gas that is returned to the upper zone is deducted from the amount of output gas produced from the well, and the remaining gas is balanced against the quantity assigned by the Alberta Conservation Board as the allowable quantity that can be produced.

The first month's production from the Four Star well after completion was 5301 brl, and the highest production ever reached in this well was 13,229 brl in March 1938, seven months after completion.

The Four Star well was the sixteenth well to be completed in the oil zone of the Turner Valley field, and at the present time is the seventh or eighth largest producing well in the field. Production of this well in December 1948 was 4473 brl, and for the first ten months of 1949 the average production was 4079 brl/month with a formation gas–oil ratio averaging 1500 cu. ft/brl.

Water is slowly moving up the structure into the wells lowest down the flank, and in the course of time will have caused all of those wells to cease natural flow. Unless application is made of gas lift or some other method, they will have to be abandoned. It remains to be determined whether encroachment of water will advance higher up the structure than the lowest row of wells down the flank, before the upper wells will have been depleted of oil profitable to produce.

OBITUARY.

GEORGE THOMSON.

GEORGE THOMSON was born in Stirlingshire, and after leaving school studied chemistry at Anderson's College under the late Prof. J. Robertson Watson. On completion of his studies, he worked in Beardmore's Parkhead forges as a chemist. In 1906 he joined the Burmah Oil Co. at their Syriam refinery, Rangoon, and remained with the company until 1911, when he was transferred to the Anglo-Persian Oil Co. Abadan, as assistant works manager.

The refinery was then on the point of going "on flow," with all the attendant worries and anxieties, and George Thomson played a prominent and conscientious part in the success of this operation.

When the writer took over as works manager in 1913, following a brief visit to Abadan while returning to Burma from leave at end of 1912, Thomson remained a staunch and loyal comrade and colleague during the strenuous years of the 1914–18 war.

This period saw the first major extension in Abadan, primarily for fuels, following the company's contract with the Admiralty. In addition, other activities had to be undertaken to enable the Mesopotamian campaign to be prosecuted with any chance of success.

Sixteen shallow-craft river gunboats of the "Fly" class were reassembled from the keel up, and launched complete in every detail, having previously been assembled in Yarrows' Clydeside yard, and sent out in "packages." They were built six at a time, and launched broadside on into the Shatt-el-Arab. Other craft, towed to Abadan as hulks, comprising tugs, paddle steamers, troop barges, etc., were fitted out, as were also four larger type river gunboats from the China coast.

All this meant a large increase in the number of skilled workmen indentured from India, and with local labour amounted to 4000 to 5000 men for whom food and temporary housing had to be found. The Abadan pay roll was doubled.

After the 1914–18 war, extensions continued, and in 1922 Thomson was appointed joint works manager with the late L. F. Baynes. He was invalided home in 1924, and on recovery joined the staff of Refineries Branch of the former F.R.G. Dept., where he remained until his retiral in 1944.

George Thomson will be remembered for his quiet, pawky humour, which caused many chuckles amongst his friends. He was painstaking and efficient in the company's service, and his passing leaves a great gap to those who knew him well.

R. G. NEILSON.

DR A. E. DUNSTAN writes :—

I would like to associate myself with R. G. Neilson's tribute to an old friend and colleague. George Thomson joined the Institution of Petroleum Technologists so long ago as 1916, and was an unwavering supporter of its activities. He became a Fellow of the Institute of Petroleum in 1939.

My recollections of him are those of a steadfast friend, a man of sound character, a technologist of no mean order, and, most of all, a colleague on whom the utmost reliance could be placed, and for whom one felt a lively affection.

His passing will indeed be lamented by all who had the opportunity of working with him.

A. E. DUNSTAN.

ABSTRACTS.

	PAGE
OILFIELD EXPLORATION AND EXPLOITATION.	
Geology	242 A
Geophysics and Geochemical Prospecting	247 A
Drilling	247 A
Production	248 A
Oilfield Development	251 A
TRANSPORT AND STORAGE	252 A
REFINERY OPERATIONS.	
Refineries and Auxiliary Refinery Plant	253 A
Distillation	255 A
Absorption and Adsorption	256 A
Solvent Extraction and Dewaxing	257 A
Cracking	257 A
Polymerization	258 A
Chemical and Physical Refining	258 A
Special Processes	259 A
Metering and Control	260 A
Safety Precautions	260 A
PRODUCTS.	
Chemistry and Physics	260 A
Analysis and Testing	265 A
Gas	267 A
Engine Fuels	267 A
Gas Oil and Fuel Oil	268 A
Lubricants	268 A
Bitumen, Asphalt, and Tar	269 A
Special Hydrocarbon Products	270 A
Derived Chemical Products	271 A
Coal, Shale, and Peat	271 A
CORROSION	271 A
ENGINES AND AUTOMOTIVE EQUIPMENT	273 A
MISCELLANEOUS	274 A
BOOKS RECEIVED	276 A

AUTHOR INDEX.

The numbers refer to Abstract Numbers.

Adcock, W. A., 1258
Alm, R. M., 1266
Anderson, E. A., 1311
Archer, F. G., 1315
Arnold, R. C., 1266
Atkins, G. T., 1216

Ballande, H. M., 1173
Ballinger, H. J., 1307
Barber, C. R., 1329
Barby, D., 1273
Barrer, R. M., 1274
Barrow, G. M., 1267
Bartels, C. R., 1221
Beaven, G. H., 1260, 1278
Berg, L., 1215
Bergstrom, R. F., 1293
Bikerman, J. J., 1296
Billingsley, H. R., 1162
Biske, V., 1275
Bisson, E. E., 1295
Blair, J. S., 1182
Blohm, C. L., 1212
Bosgash, R., 1265
Boyer, C. M., 1216
Briggs, T., 1180
Brokaw, A. D., 1187
Bromley, L. A., 1211
Browne, R. Y., 1242
Brownscombe, E. R., 1186
Burgoyne, J. H., 1323, 1324
Burman, L. M., 1315
Butlin, D. G., 1247

Cady, W. M., 1269
Camp, E. Q., 1235, 1313
Campbell, J. M., 1317
Campbell, M. H., 1249
Caris, D. F., 1317
Carsey, J. B., 1155
Cattell, R. A., 1184, 1326, 1328
Chamberlain, G. H. N., 1245
Chamberland, H. J. 1292
Chenicek, J. A., 1248
Clarke, E. L., 1242
Clayton, N., 1177
Clothier, A. T., 1312
Cockburn, J. A., 1278
Cole, R. M., 1236
Coryell, F., 1312
Coull, J., 1214
Crake, W. S., 1181

Davidson, D. D., 1236
Davey, W., 1290
Dean, M. R., 1228
Decker, W. H., 1207
Deegan, C. J., 1165
Deeter, W. F., 1234
Dent, G. M., 1244
Denyer, R. L., 1252
Dorsey, C. L., Jr., 1253
Douglas, H. W., 1279
Downs, D., 1250, 1322
Dreisbach, R. R., 1262, 1263
Druge, L. W., 1248
Duff, D., 1152, 1171, 1195, 1196

Eckstrom, H. C., 1258
Edgar, J. A., 1293
Eilers, H., 1300
Eilerts, C. K., 1315
Eliot, T. Q., 1305
Eyck, E. H. T., Jr., 1224

Feuchter, C. F., 1233
Fidler, F. A., 1252
Fisikin, J. M., 1281
Foster, L. F., 1260
Frazier, H. D., 1212
Frye, A. L., 1193
Furstoss, R. J., 1284

Gardner, F. T., 1312
Gaul, R. G., 1182
Gelus, E., 1220
Georgi, C. W., 1289
Gibson, H. J., 1286
Giovannini, E., 1303
Goddin, C. S., Jr., 1305
Goldsmith, K., 1271
Grandone, P., 1185
Greene, F., 1315
Grekoff, N., 1151
Grumer, J., 1283
Grummer, M., 1240
Gyani, B. P., 1225

Hackerman, N., 1309
Hall, J. A., 1329
Hamontre, H. C., 1315
Harrison, J. M., 1168
Hickinbottom, W. J., 1255
Hicks, T. G., 1200
Hirschkind, W., 1254
Hixon, A. N., 1265
Hobson, M., 1238
Hoffer, T. P., 1188
Holcomb, D. E., 1253
Holleyman, J. B., 1185
Hoylman, H. W., 1176
Hudson, J. C., 1316
Hyde, J. L., 1249

James, W. S., 1285
Jansen, J. R., 1229, 1230, 1231
Jarman, A. W., 1297
Jentzsch, H., 1282
Johnson, J. C., 1287
Johnson, R. L., 1295

Kallenberger, R. H., 1242
Katan, L. L., 1323, 1324
Keller, W. O., 1190
Kiefer, C. V., 1298
Kieschnick, W. F., 1186
Kleiman, G., 1221
Kraemer, A. J., 1306
Krenkler, K., 1280
Kuchinka, R., 1241
Kuo-Tsung Yu, 1214

Larsen, R. G., 1314
Lawrence, A. S. C., 1273
Leniger, H. A., 1229, 1230, 1231
Leva, M., 1240
Lien, A. P., 1266
Lietz, W. T., 1183
Livingston, H. K., 1249
Lowry, R. A., 1252, 1259

McDowell, C., 1299
McGee, D. A., 1156
Malatesta, L., 1301
Manning, E., Jr., 1220
Marlow, D. G., 1269
Marple, S., 1220
Martin, P. W., 1178
Martin, R. A., 1262
May, J. A., 1218
May, K. R., 1213
Miller, C. C., 1186
Morgan, A. I., 1211
Morse, R. A., 1190

Natta, G., 1304
New, R. W., 1243
Nisewanger, C. R., 1269

Olsen, C. R., 1232

Opperman, E. F., 1210
Othmer, D. F., 1224

Pace, B. S., 1305
Pardun, H., 1241
Peck, S. M., 1302
Phillips, C., 1235, 1313
Phillips, J. R., 1242
Pigneguy, J. H., 1250
Pino, P., 1304
Pitzer, K. S., 1267
Plantfeber, J. N., 1293
Poettmann, F. H., 1228
Poore, J. N., 1189
Popovac, D. O., 1215
Porter, C. R., 1257

Rather, J. B., 1291*a*
Reamer, H. H., 1281
Richardson, J. F., 1323, 1324
Rieder, R. M., 1222
Rose, W., 1192

Sage, B. M., 1281
Sampelayo, P. H., 1172
Sbovgi, U., 1303
Schmidt, H. R., 1309
Schulz, J. W., 1288
Shine, H. J., 1256, 1270
Shrader, S. A., 1263
Sloan, J. P., 1191
Sloss, L. L., 1159
Smit, W. H., 1272
Smith, K., A., 1264
Smith, R. V., 1315
Smith, J. C., 1227
Sneddon, R., 1154
Spengler, I. G., 1280
Steinhauser, H. H., 1223
Sterba, M. J., 1232
Stevens, L. R., 1209
Swesnik, R. M., 1161

Taylor, E. F., 1170
Thodos, G., 1238
Thompson, A. R., 1222
Thompson, C. N., 1260, 1278
Thompson, R. B., 1248
Thornton, E., 1325
Tingle, E. D., 1251
Turner, E. E., 1256, 1270

Underwood, A. J. V., 1217, 1219

Visser, G. H., 1237

Walker, R. G., 1169
Walsh, A. D., 1245, 1246
Walters, E. L., 1314
Watson, K. M., 1264
Weaver, P., 1150
Weber, G. A., 1204
Weintraub, M., 1240
White, R. R., 1223
Wiberley, J. S., 1291*a*
Wilke, C. R., 1211
Williams, A. E., 1294
Wilson, G. M., 1261
Winslow, W. M., 1268
Withrow, L. L., 1317
Wright, J. C., 1201
Wyllie, M. R. J., 1192

Zenz, F. A., 1239

Oilfield Exploration and Exploitation.

Geology.

1150. Variations in history of continental shelves. P. Weaver. *Bull. Amer. Ass. Petrol. Geol.*, 1950, **34**, 351–60.—This paper was presented before the South Texas faction of the A.A.P.G. in Mexico City. The author was the president of the A.A.P.G. in 1948–49.

He points out that some students of continental shelves consider the shore line which bounds the shelf towards the land as a hinge line the landward side uplifted, and the shelf area downwarped with extensive sedimentation. The writer, however, presents another theory, that the shore line is not the locus of any movement, but that the continental shelf and the adjacent land differ only because of the difference in respective erosive agencies. He further proposes that the significant tectonic zone is at the outer edge of the continental shelf. Evidence for the theory is drawn from a discussion of the Gulf of Mexico.

The two theories will be tested in due course by geophysical surveys and by drilling.

E. N. T.

1150a. Insides of rocks shown in movies. Anon. *Petrol. Engr*, Apr. 1949, **21** (4), B-68.—A machine named the Cinematone can take single-frame photos on a motion-picture film of an impregnated core, as successive layers are removed by a diamond grinder. The film is subsequently run through at normal speed, and the nature of the pore distribution can be studied.

C. A. F.

1151. The present state of knowledge regarding source rocks. N. Grekoff. *Rev. Inst. franç. Pétrole*, Nov. 1949, **4** (11), 591–607.—The writings of Trask and Patnode, Engler, Haseman, White, and Woolnough on oil source rocks are briefly summarized, and attention is drawn to the general belief that source rocks are fine-grained. Anærobic conditions are essential. Diatoms may be deposited with little or no contained organic matter. The Black Sea is abnormal in the high organic content of the sediment, 25–35% instead of the more usual 1·5–2·5%. The barred basin of the Gulf of Karabugas has high evaporation losses and animal life carried in from the Caspian is killed, and under the highly saline conditions the organic matter is transformed slowly into a substance resembling petroleum.

Clay minerals and diverse metals are suggested as having catalytic properties in connexion with oil formation. Bacteria are believed to be important, especially in the early stages of the transformation. Zobell has observed bacteria which can transform fatty acids into hydrocarbons, and he has discovered bacteria at a depth of 1500 ft in a salt-mine, and these bacteria were previously unknown. Hydrocarbons have also been found in bacterial cells. Radioactive bombardment of fatty acids has formed hydrocarbons.

G. D. H.

1152. Oil reserves of world up 1·5 billion barrels. D. M. Duff. *Oil Gas J.*, 22.12.49, **48** (33), 180.—Foreign oil reserves are now estimated to be 51,800,000,000 brl, compared

with 50,322,000,000 brl at the end of 1948. At the latter date U.S. reserves were 24,834,000,000 brl. Canada's reserves are placed at 1,200,000,000 brl, Venezuela's at 9,500,000,000 brl, Germany's at 150,000,000 brl.

A table gives estimated reserves by countries for Jan. 1, 1950, together with the approx 1949 production. G. D. H.

1153. Survey of oil fields. Anon. *Oil Gas J.*, 22.12.49, **48** (33), 214.—Brief notes are given on recent work in the oilfields outside the U.S.A. together with tabulated data on the discovery year, producing wells, producing depth, daily average and cumulative production, oil gravity, and producing formation. G. D. H.

1154. California regains deepest well record. R. Sneddon. *Petrol. Engr*, Apr. 1949, **21** (4), B-70.—Limoneira I, in the north Montalvo area near Ventura, was abandoned at 18,734 ft with no oil indications. The well was bottomed in the Limoneira above the Miocene.

The drilling history of the well is given. C. A. F.

1155. Geology of Gulf coastal area and continental shelf. J. B. Carsey. *Bull. Amer. Ass. Petrol. Geol.*, 1950, **34**, 361–85.—The coastal plain bordering the Gulf of Mexico in the southern part of the U.S. is tilted about 5 ft per mile towards the Gulf. This slope extends out into the open water, where the gradient is 8–12 ft/mile on top of the continental shelf, but steepens to 400–600 ft/mile off the edge of the shelf. This change of slope occurs at the 70-fathom line. This continental shelf is about 50 miles wide of Mobile Bay and 70 miles wide at the mouth of the Rio Grande, but reaches max width of 140–150 miles between these points south of the Sabine River.

Numerous salt domes have been discovered on the coastal plain, and domes have already been located by geophysical work in the open water. More than 140 dome-like topographical prominences, with relief varying from 12 to 600 ft, are present along the edge of the shelf.

The Mississippi River is building its delta across the shelf at the rate of one mile in 16 to 17 years and is now within 12–15 miles of the edge of the shelf. The natural levee along the Mississippi serves as a ramp, from which oil operations have taken place and ten or more domes are well out on the shelf; thus there is actually nothing new about oil production from this shelf area.

The author believes that the limit of depth of water in which wells can be drilled by the present method is 100 ft. At greater depth newer methods must be used, such as the construction of galleries from the land. E. N. T.

1156. Gulf activity spurred by eleven discoveries. D. A. McGee. *Petrol. Engr*, Apr. 1949, **21** (4), B-54.—Oil was first discovered on the continental shelf in the Gulf of Mexico in the Creole field in 1938. The current development programme has discovered eleven fields off the Louisiana coast, of which seven are oilfields, three gas-condensate, and one a dry gas field. In addition, several tests have found good shows of oil and gas. Extensive geophysical work was carried out in 1948, and is continuing.

Most of the structures are salt domes which vary from the shallow-piercement type to deep-seated salt masses.

Oil is produced into small separators on the well platforms, and is transported by barge to inland terminals.

A map shows the locations of the eleven fields, and a table gives location, mechanical, and production data on wells drilled off the coasts of Louisiana and Texas.

C. A. F.

1157. Gets new offshore well. Anon. *Petrol. Engr*, Oct. 1949, **21** (11), B-92.—A well drilled 7 miles off the coast of Cameron Parish, Louisiana, on test flowed 912 b.d. of 34° oil from 8823 to 8828 ft. G.O.R. was 540 : 1. C. A. F.

1158. Finals well off coast. Anon. *Petrol. Engr*, Oct. 1949, **21** (11), B-88.—Cameron A-1, 2½ miles off the coast of Cameron Parish, Louisiana, was completed for 934 b.d. of 42·3° oil from Miocene sand at 10,390–10,408 ft. C. A. F.

1159. Paleozoic sedimentation in the Montana area. L. L. Sloss. *Bull. Amer. Ass. Petrol. Geol.*, 1950, **34**, 423–51.—Isopach and lithofacies maps illustrating the record of Paleozoic sedimentation in Montana and adjacent states are presented, with interpretations of the positions and times of activity of negative and positive elements. The study indicates that the complex Cordilleran geosyncline, Williston basin, Central Montana trough, and Wyoming shelf areas were important factors in controlling sedimentation by their tectonic behaviour during deposition. E. N. T.

1160. Deep test in Lea County. Anon. *Petrol. Engr*, Oct. 1949, **21** (11), B-92.—1 J. M. Denton, in Lea County, New Mexico, on test flowed 50 brl oil in 2 hr and produced gas at a rate of 700,000 cu. ft/day from the Devonian at 11,264–11,367 ft. C. A. F.

1161. Golden trend of south central Oklahoma. R. M. Swesnik. *Bull. Amer. Ass. Petrol., Geol.*, 1950, **34**, 386–422.—The Golden Trend of South–Central Oklahoma is located in the southeastern embayment of the Anadarko basin.

In this area, oil is produced from rocks varying in age from the Permian to the Ordovician. The author, in this paper, described three type oilfields in detail. The main producing formations are various Deese (Pennsylvanian) sandstones, upper (Devonian) and lower (Silurian) Hunton limestone, Viola (Ordovician) limestones, and several formations of the Simpson group (Ordovician). Several pools produce from the Simpson group in structural traps, but most of the pools in the area produce from Deese sandstones in stratigraphic traps formed by these sandstones as they successively lap out upon the Pauls Valley uplift. E. N. T.

1162. Sholem Alechem pool presents complex anticlinal picture. H. R. Billingsley. *World Oil*, 1.2.50, **130** (2), 61.—The Sholem Alechem pool is in southern Oklahoma, is 9 miles long and up to 2 miles wide, and is now the second largest producing field in the state.

The field was discovered in 1923, and to 1947 relatively small production came from Permian Hoxbar and Deese sand lenses. Subsequent discovery of oil in the Sims sand in the Pennsylvanian Springer shale sequence increased production from 706,853 brl in 1947 to 5 million brl in 1948.

The structure is an anticline near the axis of the Anadarko–Ardmore geosyncline. It differs from the " buried-hill " type at Healdton, in that it is a tightly compressed fold of Pennsylvanian beds having a steeper dip on the north flank. The crest max shifts southwestwards with depth, and the closure, which increases with depth, is shown as a max on the Sims sands. The anticline is expressed at surface as a northwest–southeast anticlinal ridge having 200–300 ft of closure. Interpretations of the structural pattern within the Springer have shown complex fault patterns, but recent studies indicate that many of the supposed faults are lithological breaks, due to incipient erosion and channelling during sand deposition.

Oil gravity averages 30°, and has little relation to structure. C. A. F.

1163. Texas tidelands discovery. Anon. *Petrol. Engr*, Oct. 1949, **21** (11), B-86.—1 State, off Galveston Island, flowed 5,122,000 cu. ft. gas/day and 48·6 b.d. of 54° condensate from 5934 to 5958 ft. C. A. F.

1164. Gulf oil discovery. Anon. *Petrol. Engr*, Apr. 1949, **21** (4), B-106.—135 Keystone Cattle Co., in Winkler County, West Texas, flowed on test 1557 b.d. of 38·4° oil from the Devonian from above 9744 ft.

The well is 6½ miles from the Keystone Devonian field. C. A. F.

1165. Scurry play jumps north into Kent County. C. J. Deegan. *Oil Gas J.*, 22.12.49, **48** (33), 303.—1 DM Cogdell, 12 miles northeast of the North Snyder field and 1 mile inside Kent County, topped the Canyon reef at 6773 ft, 150 ft above the North Snyder water level. Cores have shown gas and good fluorescence, but no successful drillstem test has yet been made.

The reef play in Scurry and adjacent counties has shown about 800,000,000 brl of oil. G. D. H.

1166. West Texas deep well. Anon. *Petrol. Engr*, Apr. 1949, **21** (4), B-106.—1-A TXL, in north-central Upton County, flowed 1167 b.d. of 52·3° oil from 12,700 to 12,760 ft and 12,780 to 12,820 ft. C. A. F.

1167. Virginia gas field. Anon. *Petrol. Engr*, Apr. 1949, **21** (4), B-108.—A well drilled 20 miles northeast of Dante found approx 450,000 M.c.f. gas in a 175-ft Price section at 3849 ft. C. A. F.

1168. Structural features of the Canadian Shield. J. M. Harrison. *World Oil*, 1.2.50, **130** (2), 202.—Bedrock features of the Pre-Cambrian Canadian Shield, which covers approx one-half of the country, are similar to those found in other rocks forming "basement complexes" beneath known oilfields. A study of the structure of the bedrock at surface can aid the interpretation of basement structures and their effect on overlying sediments. The Canadian Shield, which is well exposed, provides an excellent opportunity for this. Structures can be determined from air photographs, since the low relief and generally scant cover provide uninterrupted views over large areas. C. A. F.

1169. Oil industry progress in Brazil. R. G. Walker. *World Petrol.*, Feb. 1950, **21** (2), 39.—Geophysical work has indicated 3000–11,000 ft of sediments in the Marajo Island basin. Geological work and seismic work has been executed in Maranham, Piaui, and Goias states, and a deep test is to be drilled. There has been further geological work in Sergipe, Alagoas, and Pernambuco with a view to locating wells.

Five oilfields have been developed in Bahia. Dom Joao, opened in 1947, is expected to be the biggest. There are seven producing horizons down to about 1150 ft. The reserves of these fields are now estimated at 24,000,000 brl, and Candeias had seventy-five wells, Lobato-Joanes seventeen, Aratu thirteen, Pitango four, and Dom Joao eleven at the beginning of 1949.

There are three skimming plants, and a rudimentary refinery. A modern refinery is being built at Mataripe. A thermal cracking plant is to be built. A tanker fleet of 180,000 tons is to be assembled.

A new petroleum law is planned which will permit foreign capital in some phases of the industry. G. D. H.

1170. Petroleum exploration in Brazil. E. F. Taylor. *Petrol. Engr*, Oct. 1949, **21** (11), B-35.—Although much of Brazil is igneous and metamorphic terrain, there are large sedimentary basins, and ten areas have been selected as petroliferous. These are the Parana basin, Alto Araguaia syncline, Eastern Coastal Plain, Maranhao–Piaui basin, Bahia Graben, Northeastern Coastal Plain, Amazon Delta, Upper and Lower Amazon basins, and the Acre Andean area. 36% of Brazil is covered by basins, in which sediments average 7200 ft in thickness.

The existing fields are in the Reconcavo of Bahia, and six have been discovered since 1938. They are the Aratu, Pitanga, Lobato-Joanes, Itaparica, Candeias, and Dom Joao fields. The Aratu field is chiefly gas, and the Pitanga field has little commercial significance.

Production in the Lobato-Joanes field is from a belt approx 800 ft wide and parallel to the eastern fault scarp of the Bahia Graben. The sand pay is 60–75 ft thick, and lies against the scarp, which dips westward.

The Itaparica field was discovered in 1942. Wells are dual completions, oil being produced from a lower sand, and gas from an upper. There is a small anticlinal structure. Average production is 50–75 b.d/well of approx 30° oil.

The Candeias field is the largest in Brazil, and is being developed. Production is from lenses at depths of 2000–4000 ft. The largest well had an initial production of more than 2000 b.d. The structure is a sharp asymmetrical anticline which is believed to be faulted. Oil gravity is approx 28°.

The Dom Joao field, discovered in 1947, has twelve producing wells and one dry. Producing sands are approx contemporary with those at Candeias and Itaparica, but are thicker and more consistent. Porosities range from 20 to 25%, and oil saturations from 60 to 70%. There are seven pays.

A refinery is being built in the Reconcavo, and it is estimated that, on its completion, total production from fields in this area will approximate 5000 b.d.

Exploration in Brazil is being intensified, and drilling and geophysical work is in progress under the supervision of American technicians, directed by the National Petroleum Council of Brazil. C. A. F.

1171. Better wildcat ratio. D. Duff. *Oil Gas J.*, 29.12.49, **48** (34), 42.—In the first ten months of 1949 forty-two exploratory wells were drilled in Venezuela, and twenty-four were producers. In 1948 there were fifty-one exploratory wells and fifteen successes. The 1949 wells were distributed as follows: nine in the Maracaibo area; twenty-seven in Barcelona; five in Maturin, and one in Barinas.

The Alturitas well, south of Machiques, is below 13,000 ft, and is reported to have had encouraging shows. The Curamichata well, south of Cumarebo, is below 7000 ft. At La Paz two semi-exploratory wells, P-104 and P-105, have given, respectively, 10,750 b.d. and 2956 b.d. In the Mara area DMC-1 is below 10,000 ft. OS-51, a semi-exploratory well in the Oficina area, has been completed as a producer.

G. D. H.

1172. Spain's oil possibilities. P. H. Sampelayo. *World Oil*, 1.2.50, **130** (2), 197.—Little systematic oil exploration has been carried out in Spain, although there are a number of scattered oil, gas, and asphalt shows. There are mud volcanoes at Hornos. Twenty wells have been drilled, and two are drilling. Several of these have had shows. The deepest well was drilled at Oliana, and was abandoned at 7639 ft.

The areas which offer best prospects are in the north (south of the Pyrenees and Cantabrian mountains), and in Cadiz province in the southwest.

In the northern area there are large anticlines which extend from Santander and Burgos to Navarro and the foot of the Pyrenees. Surface formations are Upper and Lower Cretaceous, and the anticlines generally have a Lias or Jurassic core. Oil shows are fairly abundant, especially in Wealden sands. Cretaceous gas has been found in a zone parallel to the French gas zone north of the Pyrenees. A well drilled to 5445 ft on the Senonian–Turonian dome of Gatzian produced some gas. Shows have been found in the foothills region of the Pyrenees, and along the flanks of the Pico Frentes ridge, where Albian shales and limestones are impregnated with black oil.

In the southwestern area, in Cadiz, light oil was found at Villamartin de Bornos. Two wells drilled near Bornos were dry.

Exploratory drilling in Spain has been sporadic, and the sedimentary areas warrant more serious investigation. C. A. F.

1173. Search for oil in France and its overseas territories. H. M. Ballande. *World Petrol.*, Feb. 1950, **21** (2), 32.—Pechelbronn's output averaged 1500 b.d. in 1938, but recently it was 1000 b.d., half from shallow wells and half by mining. In July 1949 a well near Soultz-sous-Forêt obtained 7300 b.d. from the Muschelkalk, but on completion the rate was 440 b.d.

Gas was discovered at Saint-Marcet in 1939. Some forty wells have been drilled (2000–1300 ft deep), and twelve have found high-pressure gas and two oil. In 1948 the gas output was 6,000,000,000 cu. ft. Plant capable of processing 40,000,000 cu. ft/day of gas is expected to recover 250,000 brl of gasoline/year. The crude oil output is small.

Near Lavaunage high-pressure gas shows have not led to production. Dense sulphurous oil has been found at St.-Jean-de-Maruéjols at about 2400 ft.

The financial structure and the concessions of the various companies are briefly ndicated.

In Algeria oil production has been obtained at Ain Zeft (Miocene at 1000 ft), Messila and Medjila (Upper Miocene at 300–500 ft). Twenty structures have been located, and five have been investigated geophysically. At Sidi Aissa oil has been found at 600–1000 ft, and also at about 2000 ft.

Gas has been found near Bizerte in Tunis. Gas was found in the Paleocene at 6000 ft at El Haroun; the Albo-Aptian showed gas at 4400 ft at Sidi Abder Rhamane, and there were signs of oil deeper. Light oil impregnation has been found in the Lower Cretaceous in wells in Zaouia. Tselfat, bou Drââ, and Ain-Hamra in Morocco are nearly exhausted. Oued Beth was discovered in 1947.

The financial structure of the companies operating in French overseas possessions is indicated. G. D. H.

1174. Australian petroleum industry. Anon. *Petrol. Engr*, Oct. 1949, **21** (11), B-16.—Seepages of oil and gas in Australia were first reported in 1911, and additional shows have since been found. Mainland occurrences have generally been limited to minor gas flows and small amounts of wax and bitumen in water wells and occasionally at surface.

Exploration is in progress in Papua, Queensland, and Victoria. Since exploration commenced, 268 test wells have been drilled and exploration expenditure to the end of 1948 totalled £7,500,000. Most of the wells have been drilled on scant geological data, and many areas remain "not proved." C. A. F.

Geophysics and Geochemical Prospecting.

1175. 1948 geophysical activity. Anon. *Petrol. Engr*, Apr. 1949, **21** (4), B-106.—Seismic operations in the U.S. in 1948 were increased by 17·4% over 1947, and similar substantial increases were made in world-wide operations. Expenditure on geophysical operations in the U.S. in 1948 was $125 million, approx 2·5 cents/brl oil produced in the U.S. in that year. C. A. F.

1176. Airborne magnetometer profiles across Cuyama Valley. M. W. Hoylman. *Oil Gas J.*, 29.12.49, **48** (34), 55.—NE–SW profiles 1 mile apart have been flown across the Cuyama Valley crossing the San Andreas and Nacimento faults. The flying height was 6000 ft, with 500 ft clearance over the Caliente Ridge. Three profiles are discussed with the aid of diagrams. In the southwestern part of the most southerly profile there is close correspondence between topography and the form of the magnetic profile, but a marked jump in intensity occurs on crossing the San Andreas fault, suggesting more basic basement in the northeast.

The second profile crosses the Russell Ranch oilfield. The southwestern end is considered to indicate a possible graben, while a change in the basement is again indicated on crossing the San Andreas fault. Topography and magnetic profiles do not agree. The third profile is 2 miles to the northwest, and differs from the others except in the northeast.

The profiles are believed to indicate basement faults. Two-level flights should help, and ½-mile profile spacing is desirable for detail. G. D. H.

1177. Seismic problems in reef shooting. N. Clayton. *World Oil*, 1.2.50, **130** (2), 69.—The North Snyder field of Scurry County, Texas, was discovered in 1948, and it produces from the Middle Pennsylvanian Canyon reef limestone. There are a number of fields in the area which produce from the Canyon, and it is not known whether these are a chain of reefs or local build-ups on a single reef mass. Reefing may be restricted to the Canyon, or it may extend down to the Strawn. The North Snyder reefs differ from those previously discovered in West Texas, in that there is no appreciable structural relief above the reefs.

Seismic mapping is possible only in local areas. There are few persistent markers below the reef, and over most of the southern part of the structure reflections are obtained from the reef top. The most persistent marker is from a point near the base of the Permian lime, where structural relief is small. Surface conditions impair record quality. C. A. F.

Drilling.

1178. Fishing tools and methods. P. W. Martin. *Petrol. Engr*, Mar. 1950, **22** (3), B-7.—Fishing jobs may be classified as follows: (1) stuck drillpipe tubing, liners; (2) lost items in well bottom; (3) salvaging casing, and removal of pipe in producing wells. In (1) the stuck point may be located by an electronic device and the pipe cut mechanically, or backed off at a joint by a "jet" tool or by explosives. The stuck pipe is then washed over and the process repeated.

With (2) as a last resort a jet bottom-hole cutter may be used to fragmentize the lost items.

Methods similar to (1) may be used for (3).

To locate collars and tool joints sonic devices may be used. The application of the various types of tools is described. C. G. W.

1179. Dry ice prevents blowout. Anon. *Petrol. Engr*, Feb. 1950, **22** (2), B-52.—When oil and gas threatened to blow out in a well drilled from a platform 7 miles offshore in the Gulf of Mexico, mud in the drill pipe was frozen by means of dry ice (solid CO_2). This enabled the top joint of drill pipe to be broken and a positive shut-off installed. Early attempts to freeze water in the pipe failed owing to the effect of oil and gas. C. G. W.

1180. It hangs by a thread. F. Briggs. *Petrol. Engr*, Mar. 1950, **22** (3), B-38.—History and elementary principles of screw-threads are outlined. The importance of accurate threads, particularly of tapered threads as used in the oil industry, is emphasized. The reasons for failure of tool-joint threads and remedies for thread failures are described. Good maintenance practices are laid down. References are appended. C. G. W.

1181. Automatic drilling feed controls for rotary drilling rigs. Part 1. W. S. Crake. *Petrol. Engr*, Dec. 1949, **21** (13), B-46.—Other factors being equal, the maintenance of constant load on drilling bits will result in more footage per bit and more footage per unit of time. By keeping constant weight on the bit, the rotary speed steadies down in any given formation and the table behaviour indicates formation types and formation changes.

In designing an automatic system to give constant bit load, it is first necessary to determine the relation of bit load to hook load. The drilling system is analysed to determine loadings, the strain in the system determined, and the forces acting on the string and their effect on hook load, when "feeding off," are evaluated. This analysis indicates that hook load becomes self-balancing under steady state conditions, over a wide range of variation forces. It is argued that the value given by an accurate indicator is very close to the true bit loading.

It is pointed out that to use bottom-hole measurements of bit load would necessitate damping of variations to the same order as surface readings, and also would increase the time lag between signal control action and re-signal.

A control system consists of: (*a*) Pick-up or measuring devices. (*b*) Transmission. This must give time for signals to reach and actuate the controller, and make the necessary adjustments. The delay must also be sufficient for the drilling system to settle downto the new conditions. If a suitable time delay is not incorporated a stable, flexible control system is impossible. (*c*) Brake. This must be sensitive to the slightest motion of the controlling mechanism. Variations in friction characteristics over small ranges of adjustment, and high static friction are highly undesirable. (*d*) Control instruments. A sensitivity adjustment, to determine the rate of brake force applied per unit of controlled variable charge, is necessary.

The requirements of various controls and their maintenance are described. C. G. W.

1182. Power rig requirements for deep drilling in Trinidad. J. S. Blair and R. J. Gaul. *J. Inst. Petrol.*, 1950, **36**, 105.—Based on discussions with local operators and upon recently published technical papers, the salient points to be considered in the selection of a power rig for deep drilling in Trinidad are discussed. A. R. W. B.

Production.

1183. The performance of the Ten Section oil field. W. T. Lietz. *Petrol. Tech.*, Sept. 1949, **1** (9), *A.I.M.M.E. Pap. No.* 2643, 251–8.—Ten Section produces from the Stevens sand (Upper Miocene) on a dome with closure of 350 ft and dips of about 7°. The sand shows three main zones. The upper has a primary gas cap covering 930 acres; the second had no gas cap initially. Porosities range 15–30%, and intersitial water is about 40%. Permeabilities range 10–3000 mD and average 140 mD. The initial pressure was 3525 p.s.i., although crude analysis indicated a bubble point of only 2920 p.s.i.a. The oil viscosity at reservoir temperature (211° F) and pressure was 0·4 cp. The initial oil content of the Stevens sand was 340,000,000 brl of reservoir

oil (240,000,000 brl tank oil with 199,000,000 M.c.f. of dissolved gas). The gas cap occupied 60,000,000 brl of pore space and contained 72,000,000 M.c.f. of gas.

The field was discovered in 1936, and development on 20-acre spacing was completed in 1941. After various studies and calculations it was concluded that it was not possible to produce the field under water-drive. In 1941 some wells showed gas to be channelling from the gas cap, and it was inferred that production by gas drive or pressure maintenance in the first horizon was not feasible. 10-acre spacing was adopted in the central part of the second horizon, and the possibility of greater recovery efficiency and the known sand irregularities made this attractive.

The field has been produced by depletion with controlled withdrawal from the gas cap to minimize blow-through. G. D. H.

1184. Report of Petroleum and Natural-Gas Branch Fiscal Year 1948. R. A. Catlett and others. *U.S. Bur. Mines Inf. Circ., No.* 7532, Dec. 1949.—During 1948 the U.S. Bureau of Mines carried out research on oil and gas production, transport, chemistry and refining of petroleum, thermodynamical properties of hydrocarbons, and the processing and utilization of incombustible helium. This report summarizes this research.

Reports were published on problems of gas-condensate production, including one giving the results of tests of steels, and alloys for resisting corrosion in gas-condensate wells.

Engineering studies were made of the following fields: Lake Creek, Sheridan, and West Red River, in Texas; Atlanta, Arkansas and Boggs, in West Virginia.

Studies to determine the characteristics of oil–gas solutions under reservoir conditions have been made in the North Lindsay field, Okla., Elk Basin field, Wyoming, and Rangely field, Colorado. At North Lindsay the deep-seated oil has a viscosity less than that of water. At Elk Basin and Rangely the oil–gas solutions vary in composition within the reservoirs, depending on structural position.

Engineering studies have been made on well spacing and secondary recovery methods.

The availability of fuels for all types of I.C. engines is the primary research project in petroleum chemistry and refining. Total production of high-sulphur crude reached a new record in 1946.

Research on the utilization of helium includes studies of the use of the gas as a tracer to mark oil and gas movement within the native reservoir. C. A. F.

1185. Injection rates and pressures for water flooding Mid-Continent oil sands. P. Grandone and J. B. Holleyman. *U.S. Bur. Mines Rep. Invest., No.* 4600, Dec. 1949.—The effectiveness of methods used in water flooding has been tested. The test procedures and results of a study of rates and pressures used for injecting water in several sands of the mid-Continent fields are given in detail.

Opinions differ on the optimum pressures and rates for water injection. There are four main types of water break-through in sands: channelling through oil-depleted zones, by-passing through natural cracks and fissures, by-passing through water and gas sands, and by-passing through formation ruptures caused by the application of pressures in excess of the critical input pressure.

Periodic measurements of the injectivity index of the input well (intake cap/unit pressure differential at sand face) are useful in following intake characteristics of the well and to predict the need for remedial measures. The injectivity index and critical input pressure are determined as follows. The input well is shut down until the w.h.p. reaches equilibrium, and the instantaneous input rates are then measured for periods of 5 min, starting with shut-in conditions and increasing rate with pressure in steps until full line pressure is reached. The pressure and rate relationships are linear, and the crit input pressure is shown as an inflection point on the curve. The slope of the curve at pressures below the crit input pressure is the well injectivity index.

Tests based on the above procedure were made on input wells in shallow Pennsylvanian shoestrings in Kansas and Oklahoma, and in Permian sands in north-central Texas.

Results show that there is no correlation between specific injectivity index and physical characteristics of the sand, but that the crit input pressure is related to these characteristics, and to depth. C. A. F.

1186. A calculation of the effect of production rate upon ultimate recovery by solution gas drive. C. C. Miller, E. R. Brownscombe, and W. F. Kieschnik. *Petrol. Tech.*, Sept. 1949, **1** (9), *A.I.M.M.E. Tech. Pap. No.* 2565, 235–47.—The possibility has been considered that large pressure gradients in a solution-gas-drive field arising from high producing rates might lead to a lower ultimate recovery than under a low producing rate. The reservoir conditions accompanying a high producing rate and the corresponding ultimate recovery have therefore been compared with those for a reservoir produced at some marginal rate throughout its life. In the calculations fluid flow–material balance analysis has been applied to a series of successive steady state conditions in the reservoir. For the case studied, very little difference in recovery was obtained at the abandonment pressure. It is also indicated that similar results would be obtained over a considerable range of variations in the properties of reservoir fluids, formation permeability, or well spacing. Even if the reservoir has a potential water drive it appears that no harm will be done by open-flow production if the rate is reduced before any appreciable amount of free gas is produced. However, any condition which leads to disproportionate withdrawal rates and which causes large pressure differences over large areas might lead to a substantial reduction in ultimate recovery. G. D. H.

1187. Corrections of gas volumes for compressibility and temperature. A. D. Brokaw. *Petrol. Tech.*, Sept. 1949, *A.I.M.M.E. Tech. Pap. No.* 2698, 248–50.—Charts for gas-specific gravities of 0·6, 0·65, 0·7, 0·75, and 0·8 are given, whereby gas volumes can be corrected for temperature and deviation from Boyles Law. Pressures up to 6000 p.s.i.a. are covered, and temperatures up to 300° or 350° F.

Estimates of gas reserves for gas-condensate wells must be based on the composition or the specific gravity of separator gas, otherwise the result will be too high. Although the compressibility of the reservoir gas in such fields is greater than that of the separator gas, the excess compressibility is not sufficient to offset the shrinkage due to condensation. G. D. H.

1188. New selective cross-over packer. T. P. Hoffer. *Petrol. Engr*, Dec. 1949, **21** (13), B-58.—During the flowing life of a dually completed well it may be necessary to switch or cross-over the flows from zones after the well is placed on production. To avoid the necessity of killing the well and pulling the tubing, a new cross-over packer has been developed. Change-over is accomplished by a wire line on which are landed two types of wire-line chokes.

The tool is an anchor-type packer with an upper- and lower-opposed pressure-sealing element. The packing elements are mounted on the main body of the packer. Above the elements the body of the packer is extended, and incorporates a landing nipple and locking recess to accommodate one of two types of wire-line chokes. The chokes are normal side-door and modified side-door types respectively.

Construction and operation are described. C. G. W.

1189. How to reduce oil well pumping costs by power factor improvement. J. N. Poore. *Petrol. Engr*, Mar. 1950, **22** (3), B-57.—The advantages of high power factor $\left(=\frac{\text{power amperes} \times \text{volts}}{\text{total amperes} \times \text{volts}}\right)$ in reducing costs in electrical installations are outlined. Methods of improving power factor (*e.g.*, installing capacitors) and reasons for low power factor are described. C. G. W.

1190. Some examples of fluid flow mechanism in limestone reservoirs. W. O. Keller and R. A. Morse. *Petrol. Tech.*, Aug. 1949, **1** (8), *A.I.M.M.E. Tech. Pap. No.* 2638, 224–34.—In limestone reservoirs the distribution and degree of continuity of the pore systems and the relative volumes and permeabilities of the systems making up the complex cause large variations between the performance of individual limestone reservoirs and their susceptibility to secondary recovery methods. The effects of these factors on the mechanism of fluid flow cannot be adequately assessed under present concepts, laboratory and geological data.

At present the observation and interpretation of the performance of individual limestone reservoirs provides the best approach for evaluating the summate effects on

performance of the many, now immeasurable, variations in the properties of limestone reservoirs.

The behaviour of four limestone reservoirs is discussed. It is shown that there are undoubtedly cases where gas injection leads to increased producing rates.

G. D. H.

1191. Phase behaviour of natural gas and condensate system. J. P. Sloan. *Petrol. Engr*, Feb. 1950, **22** (2), B-54.—The general properties of condensate reservoirs are discussed. The value of laboratory experiments on condensate hydrocarbons is emphasized. In carrying out recombination experiments on separator gas and condensate, accurate sampling is of vital importance. An apparatus is described for carrying out recombination experiments and results presented.

Data enable determination of condensation and volumetric behaviour of a given hydrocarbon mixture. The behaviour of the mixture under pressure-depletion conditions may also be studied. C. G. W.

1192. A note on the theoretical description of wetting liquid relative permeability data. W. Rose and M. R. J. Wyllie. *Petrol. Tech.*, Sept. 1949, **1** (9), 45.—The following relationship for wetting liquid relative permeability is derived :—

$k_{rw} = \frac{T}{T_e} S_w^2$, where k_{rw} = wetting liquid permeability, S_w = wetting liquid saturation, and $T = \left(\frac{L_a}{L}\right)^2$. L = bed length, L_a = average tortuous pore length. $T_e = \left(\frac{L_{as}}{L}\right)^2$ where L_{as} = average length of current path in a partially saturated core.

The equation is checked against Wyckoff and Botset's data.

If the above relationship and that derived by Thornton are correct, then $P_c = P_d/S_w^{\frac{1}{2}}$, where P_c = capillary pressure and P_d = displacement pressure. This equation is too simple to describe accurately the capillary pressure of all porous media. In some cases neither Thornton's nor Rose and Wyllie's equation fits the experimental data, but the latter may have an advantage, since it does not depend on capillary pressure under dynamic flow, a factor for which no satisfactory measuring technique has yet been devised. G. D. H.

1193. Well treating chemicals. A. L. Frye. *Petrol. Engr*, Feb. 1950, **22** (2), B-14.—A procedure is described for determining the effectiveness of well-treating fluids in washing and cleaning well samples. Representative samples are obtained by careful selection of bailings cores and sidewall samples.

One important cause of declining production is plugging of producing channels by foreign fluids, solids such as mud, scales, and bitumen, etc.

The effectiveness of various treating agents is determined by placing equal amounts of the sample in tared-screen containers which correspond to the annular section of the well. The treating agents are then circulated through the screen and across the face of the samples. The rate of washing is kept low so that material is not removed hydraulically. With difficult samples rate of washing is increased till sample disintegrates. Weighing of drained samples in conjunction with volumetric tests indicates effectiveness of washing.

The importance of carefully standardizing test conditions is emphasized. Results of a typical test are given. C. G. W.

1194. Improved recovery of petroleum announced. Anon. *Petrol. Engr*, Feb. 1950, **22** (2), B-18.—A method of recovering petroleum by injecting hydrocarbon gases under very high pressures is announced. Solution of gas in the crude oil, and of oil in the gas at these pressures cause expansion of the oil giving a single homogeneous phase. Laboratory experiments indicate possible recoveries of 90%. The expense of the method is considerable. C. G. W.

Oilfield Development.

1195. New production high. D. M. Duff. *Oil Gas J.*, 22.12.49, **48** (33), 130.—Outside Russian-controlled areas and the U.S.A., the October oil output averaged 3,643,600 b.d. The world total is estimated at 9,512,100 b.d.

In October Venezuela gave 1,431,000 b.d., Colombia 78,700 b.d., the Middle East 1,428,600 b.d., British Borneo 72,000 b.d., and Indonesia 125,000 b.d.

Tables give the daily output by countries for September and October, Venezuelan production by companies and monthly during the period January–October 1949, and the monthly outputs for major areas. G. D. H.

1196. Foreign crude production rises 10·2%. D. M. Duff. *Oil Gas J.*, 22.12.49, **48** (33), 177.—Outside the U.S.A., Russia, and eastern Europe the daily average oil production in 1949 is estimated at 3,433,000 b.d., Russia and eastern Europe are credited with 803,100 b.d. World production is estimated at 9,279,800 b.d., a decline of about 0·8% compared with 1948. Venezuela is estimated to have produced 1,320,000 b.d., Colombia 82,300 b.d. (a record), Germany 16,300 b.d., Holland 11,600 b.d., Italy 200 b.d., France 1000 b.d., Egypt 42,500 b.d. (a record), the Middle East 1,367,100 b.d., and the Far East 197,800 b.d.

A table gives the daily production by countries for each year from 1938 to 1949, and for 1908, 1918, and 1928. G. D. H.

1197. Western Germany's output up. Anon. *World Oil*, 1.2.50, **130** (2), 200.—Production in Western Germany in 1949 was approx 6 million brl, a 32·4% increase over 1948, and sufficient to meet approx one-third of the country's domestic requirements. Future production is estimated at 15 million brl/year, providing drilling and production equipment is available.

Production from the Georgsdorf field rose from 371,672 brl in 1948 to 934,000 brl in 1949. Production from Emlichheim showed a 99% increase over 1948. Yields have also risen from Steimbke, Wesendorf, Hademsdorf, Broistedt, Oberg, Calberlah, Gifhorn, and Nienhagen–Haenigsen. Declines at Eicklingen and Etzel continued.

Seven new fields were discovered in 1949. These include Ruehlertwist–Ruehlermoor, Scheerhorn in Emsland, and Elpersbuettel in Schleswig-Holstein. C. A. F.

Transport and Storage.

1198. Speed and power economics of big tankers. Anon. *Oil Forum*, Mar. 1950, **4** (3), 113.—American companies have taken delivery of the major part of a costly fleet of 16-knot post-war super-tankers. They are geared steam-turbine propelled, and contrast with current European practice, which claims that the modern diesel engine is the more efficient system and that a speed of 14 knots offers a better economy. The paper brings out the relevant points of both systems. A. S.

1199. Speed Kuwait tank farm and terminal operations with electric controls. Anon. *World Petrol.*, 1950, **21** (3), 60–1.—Description is given of the electrical remote-control and indicator systems being installed to operate valves and to gauge tanks in a thirty-eight tank farm and connexions to wharves. Controls are interlocked to prevent diversion or mixing of streams. Valves are operated by 440 V (A.C.) motors and level gauge circuits operate on 110 V (A.C.); remote control and indicator circuits use 24 V (D.C.). E. B.

1200. Planning modern gas-compressor stations—5. T. G. Hicks. *Oil Gas J.*, 16.3.50, **48** (45), 95.—Part 5 deals with safety devices, station heating, and miscellaneous equipment.

A table summarizes most of the important safety devices in modern stations, classified according to substance or element controlled.

Compressor buildings can be heated from waste-heat boilers, and jacket-cooling, water-circulatory systems.

Miscellaneous equipment includes auxiliary building for air-compressors and storage buildings for thermometers, pressure gauges, and speed indicators and their maintenance. G. A. C.

1201. New displacement method of measuring gas flow through pipe lines. J. C. Wright. *Oil Gas J.*, 16.3.50, **48** (45), 99.—Flow efficiency between two points on a

pipeline can be determined by means of a formula provided from data obtained by ammonia-displacement method.

The volume in a known length of pipeline is calculated, upstream and downstream pressures, gas temperatures, and barometric pressures are taken.

The time elapsing between first discoloration of test paper after injection of ammonia, until the last trace of ammonia-laden gas passes the sample tube is recorded.

A study of an 18-mile section of pipeline is given.

Cost of method is very small, and cost of material negligible. G. A. C.

1202. Reconditioning A-1000. Anon. *Pipe Line News*, Feb. 1950, **22** (2), 21.—A method of reclaiming pipe is described. The reclaiming device consists of three main parts. The first section rests on top of the pipe and clears dirt covering the pipe. The second section consists of a curved shoe, fitting under the pipe, which cuts dirt from beneath the pipe. The last section is a wedge-shaped shoe which fits under the pipe and starts the pipe out of the ditch. The machine is drawn by as many tractors as necessary usually three to five, and is followed by two side-boom tractors which lift the pipe out of the ditch and lay it to one side. A pipe-cleaning machine follows, and then the pipe is cut into suitable lengths with cutting torches. C. G. W.

1203. Gulf of Coro crossing on New Creole Line. Anon. *Pipe Line News*, Feb. 1950, **22** (2), 11.—Production at Lake Maracaibo being 450,000 b.d. and the lake being inaccessible to large, deep-draft tankers, a pipeline was an economic necessity.

The route decided on crossed the Gulf of Coro. Winds in this area blow at a steady 45 m.p.h., and the gulf being shallow, waves up to 15 ft high are formed. A further difficulty was the presence of teredos-marine borers, which cut through most types of pipeline coverings. The coating finally used was glass wool, enamel, felt, wire mesh, covered with a dense concrete coating. This brought the weight of the 26-in-dia pipe up to 285 lb/ft. The shallow water did not permit the usual heavy marine equipment to be used. Initially piles were driven across the gulf at 300-ft intervals on the leeward side, and the pipe floated out. It was hoped that the wind would hold the pipe against the pilings. In practice, it was found that when the tides ran the opposite way the pipe was torn from the pilings. A second row of piles was driven parallel to, and 20 ft to windward of, the first row, and the pipe fed into the runway so formed. This proved satisfactory for a time until wind and tide drove the pipe out of the piling channel, cracking the pipe. The final method adopted was to sink all but the end of the pipe by filling with water, and welding the floating end to a floating section, the ends to be welded being held in a floating cradle. As each weld was completed all but the end of the section was sunk, and another floating section welded on to it.

The 15 miles of the Gulf were crossed in eight weeks. C. G. W.

Refinery Operations.

Refineries and Auxiliary Refinery Plant.

1204. Blueprint of 1950 refining. (39 processes indexed.) G. A. Weber. *Oil Gas J.*, 23.3.50, **48** (46), 171.—The principle features of thirty-nine refining processes are given, together with a flow sheet for each process. Processes include various forms of catalytic cracking, coking, isomerization, solvent extraction and deasphalting, distillation, wax manufacture, sweetening, and ethylene production. G. A. C.

1205. Chemical engineering unit operations. (Fifth Annual Review.) *Industr. Engng Chem.*, 1949, **42** (1), 13–76.—The present review contains sixteen sections, including adsorption and humidification, adsorption, high-temp distillation, high-vacuum distillation, solvent extraction, fluid dynamics, heat transfer, and materials handling. An extensive bibliography is appended to each. R. G. T.

1206. Steam jet cools ethyl processing plant. Anon. *Oil Forum*, Mar. 1950, **4** (3), 107.—The new Ethyl manufacturing plant for producing anti-knock compounds makes use of an interesting unit to supply part of its requirements for cooling water, called a steam-jet refrigeration system. The jet unit evaporates a small portion of the

water at an artificially low pressure, and the evaporated water carries away with it heat from the remaining unevaporated water, with the result that the latter is quickly cooled. About a hundred times as much heat is required to convert a pound of water into steam as is given up by a pound of water in being cooled 10° F. For that reason, only a very small fraction of the warm water entering the evaporator can, by flashing into steam, provide the refrigerating effect by cooling the remainder. The actual process in practice is described. A. S.

1207. Economics of power generation. W. H. Decker. *Oil Gas J.*, 23.3.50, **48** (46), 232.—The design, control, and economics of the steam- and power-generating plant at the East Chicago refinery of the Sinclair Refining Co. is described.

The equipment consists of a water-treating unit, three 125-p.s.i., two 400-p.s.i., and three 900-p.s.i. outdoor-type boilers, with three 6000-kW electrical generators.

Both the 400- and 900-p.s.i. boilers are high-efficiency units equipped with forced- and induced-draft fans and regeneration-type air pre-heaters.

Data shows that there is a large saving to be realized from by-product power generation; and that actual expenditure for generated energy is small in comparison with cost of same amount of purchased power. G. A. C.

1208. Pure's modern lube-manufacturing facilities. L. B. Stevens. *Oil Gas J.*, 16.3.50, **48** (45), 76.—The grease compounding and blending plant at the Smiths Bluff Refinery, Nederland, Texas, of the Pure Oil Co. is described.

Units include those for manufacture of calcium and sodium soap greases, extreme-pressure products, gear-shield and wire-rope greases, cutting oils, motor and industrial oils.

Over 1000 forms and varieties of lubrication products are made and marketed in various-sized packages. G. A. C.

1209. Vaporizing burner trouble. Anon. *Fuel Oil & Oil Heat*, Mar. 1950, **9** (3), 60.—It was concluded that all complaints about pot-type vaporizing burners were caused by poor combustion. Service steps taken were :—

(1) the pot burner was levelled;
(2) data were obtained on g.p.h. rate most likely to produce clean combustion, and the burner was adjusted for this rate;
(3) soot and carbon was cleaned from the burner, furnace-heating surfaces, and smoke-pipe and chimney flue;
(4) leaks were located and sealed.

The reason for poor combustion was that the furnace unit was of two or three times the capacity necessary, and the furnace temp was never high enough for good, clean combustion.

The temp of the furnace's direct-heating surfaces was raised considerably to offset its being oversize. This was done by enclosing the main part of the furnace in a shield of sheet metal.

A diagram shows its position. D. K.

1210. Pumps for handling fuel oil. E. F. Opperman. *Heating & Ventilating*, Mar. 1950, **47** (3), 60.—Reciprocating and gear pumps are used for handling fuel oil, and the latter type is the more popular except where high-pressure steam is available and where high oil pressures are desired. The gear pump is classified into two divisions—the external-gear and the internal-gear types. These are described with the aid of drawings. A further drawing shows a typical installation with outside storage tank and wall pump, and the paper concludes with a description of this. A. S.

1211. Effect of surface tension on heat transfer in boiling. A. I. Morgan, L. A. Bromley, and C. R. Wilke. *Industr. Engng Chem.*, 1949, **41** (12), 2767–9.—The surface tension of a "young" surface is shown to control the effect of surface tension charge on H.T.C.s. Decreasing surface tension of a boiling liquid increases H.T.C.s when nucleate boiling persists. The crit temp difference occurs at lower values of the temp difference as the surface tension is lowered. R. G. T.

1212. Chemical deterioration of cooling-tower lumber. C. L. Blohm and H. D. Frazier. *Oil Gas J.*, 16.3.50, **48** (45), 72.—Delignification in wooden cooling towers results in leaving the wood residue as a fibrous, cellular structure of extremely low strength, with final failure.

A survey of some 500 cooling towers has been made; and laboratory experiments made on redwood, cypress, and yellow pine by immersing specimens in test solutions for sixty days.

A table shows per cent loss in wt of the woods after immersion in sodium carbonate, calcium sulphate, and magnesium sulphate solutions of various pH values.

Results show the undesirability of sodium carbonate in cooling-tower waters, and necessity of control of pH value between 7·0 and 7·5. Excessive chlorine must also be avoided. Periodic hosing of aerator and structural members, and treatment of sections with materials which reduce transfer of sodium carbonate containing water through wood structure increase resistance to delignification.

Five figures illustrate the article. G. A. C.

1213. An improved spinning top homogeneous spray apparatus. K. R. May. *J. appl. Phys.*, 1949, **20** (10), 932–8.—An apparatus is described which produces homogeneous mists or clouds of liquid or solid particles of any desired size. The arrangement is a modification of Walton's original model, in which liquid is sprayed by a Beams high-speed air-driven top. The present apparatus shows advantages over the original model in regard to both construction and operation. Unwanted satellite drops are extracted automatically. The apparatus is very suitable for use with oils.

D. F. J.

1214. Adiabatic and non-adiabatic rectification. Kuo-Tsung Yu and J. Coull. *J. Inst. Petrol.*, 1949, **35**, 770.—The process of distillation is classified into two types, the adiabatic and the non-adiabatic rectification. The process of non-adiabatic rectification is developed from two points of view, as a distillation process in unit operations, and as a heat process in thermodynamics. The method of calculating the number of heat-adding and heat-abstracting zones for continuous and batch operation, and the calculation of the min number of zones required are presented. The thermodynamic basis of formulating the min work required for the adiabatic and non-adiabatic rectification is outlined by applying the principles of the second law. A. R. W. B.

1215. Effect of reduced pressure on efficiency of a packed rectification column. L. Berg and D. O. Popovac. *Chem. Engng Prog.*, 1949, **45** (11), 683–91.—A study is presented of the effect of reduced pressure on the efficiency of a packed rectification column. A 2-ft column of 1 in dia packed with ¼-in stainless-steel Fenske helices was employed with a test mixture of *n*-octane–toluene at pressures from 20 to 760 mm Hg abs. Results obtained indicate that column efficiency is independent of pressure. Design calculations may be based on vapour–liquid equilibrium data determined at the same pressure as that at which the column is to operate, the H.E.T.P. of a given packing remaining constant. J. G. H.

Distillation.

1216. Application of McCabe–Thiele method to extractive distillation calculations. G. T. Atkins and C. M. Boyer. *Chem. Engng Prog.*, 1949, **45** (9), 553–62.—A calculation procedure employing the McCabe–Thiele graphical method for making extractive distillation calculations is presented. The method and data used were obtained in the wartime operation of the feed-preparation section of a petroleum–butadiene plant, and further applications are indicated. Fundamental relative volatility data for the separation of the various saturated and unsaturated butanes in the presence of acetone as solvent are presented, together with data indicating the effect of feed rate, reflux rate, and solvent rate upon butylene recovery. J. G. H.

1217. Fractional distillation of multi-component mixtures; a numerical example. A. J. V. Underwood. *Chem. Engng Prog.*, 1949, **45** (10), 609–18.—The method presented in a previous paper (*Chem. Engng Prog.*, 1948, **44** (8), 603) is illustrated by numerical computation for a five-component mixture. J. G. H.

1218. Minimum reflux ratio for multicomponent distillation. J. A. May. *Industr. Engng Chem.*, 1949, **41** (12), 2775–81.—Comparison of results with computation following the Underwood method show that at minimum reflux multi-component systems may be resolved into several binary mixtures to determine minimum reflux ratio. The principles presented are applied to all types of separation except those involving distributed components or "split keys." This type may be solved by modification of the general procedure. Calculations are apt to be more time-consuming than the Underwood method, and the latter is then to be preferred. When $q = 1$ or $q = 0$, and no components lighter than the light key or heavier than the heavy key are present, the method is as simple and speedy as the Underwood method, and both methods are as rapid as the empirical method. R. G. T.

1219. Fractional distillation of multicomponent mixtures. Number of transfer units. A. S. V. Underwood. *Industr. Engng Chem.*, 1949 **41** (12), 2844–7.—A method of calculating the number of transfer units required for the fractionation of multi-component mixtures. Constant relative volatility and molal reflux are assumed. R. G. T.

1220. Technique of performance studies of commercial fractionators. E. Gelus, S. Marple, Jr., and E. Manning, Jr. *Chem. Engng Prog.*, 1949, **45** (10), 602–8.—The value of determining the fractionating efficiency and internal vapour and liquid loading of a bubble-tray column is remarked, and applications of the data are indicated. The technique used in evaluations on columns which were in service and could not be released for test purposes are described. The steps outlined comprise obtaining test data, analysis, stream-flow distribution and material balancing, choice of equilibrium data, fractionation and loading calculations, and critical examination of results. J. G. H.

1221. Solvent fractionation with immiscible solvents. C. R. Bartels and G. Kleiman. *Chem. Engng Prog.*, 1949, **45** (9), 589–94.—A simplified mathematical approach for determining the effect of process variables on liquid–liquid fractionation is presented. Material-balance equations are derived and plotted as a family of curves from which a graph is prepared relating recovery and purification with number of plates and feed points. Worked examples illustrate applications to the extraction of antibiotics. J. G. H.

1222. Vapour–liquid equilibria measured by a Gillespie still–Ethyl alcohol–water system. R. M. Rieder and A. R. Thompson. *Industr. Engng Chem.*, 1949, **41** (12), 2905–8.—Vapour–liquid equilibrium data for ethyl alcohol–water system were obtained with the Gillespie still and shown to agree with earlier values. Boiling-point data can be obtained simultaneously. Modification of the Gillespie still is recommended to enable equilibrium to be attained more quickly. R. G. T.

1223. Vapour–liquid equilibria data for ternary mixtures—methyl ethyl ketone–*n*-heptane–toluene system. H. H. Steinhauser and R. R. White. *Industr. Engng Chem.*, 1949, **41** (12), 2912–20.—Several methods for checking of the thermodynamic consistency of experimental data for the above system by the Gibbs–Duhem equation are described. Curves are included, and the data are also represented by Redlich and Kister's empirical equations. R. G. T.

1224. Correlating azeotropic data. D. F. Othmer and E. H. T. Eyck, Jr. *Industr. Engng Chem.*, 1949, **41** (12), 2897–900.—Logarithmic plots are shown to give straight-line relations for pressures, partial pressures, compositions (vapour and liq), or activity coeffs of binary or ternary azeotropic mixtures when plotted against total pressure or against a temperature scale derived from vapour pressure of a reference substance. Thermodynamic proof is included and is derived on assumption that $x = y$ rather than of const temp, pressure, and vol. R. G. T.

Absorption and Adsorption.

1225. Distribution law, adsorption, and chemical reaction II. B. P. Gyani. *J. Phys. & Colloid Chem.*, 1949, **53** (7), 1091–101.—Adsorption is considered as a special kind

of distribution of substances between two phases. It is considered that uniform distribution of the adsorbed substance on the adsorbing surface is unlikely. Systems in which adsorption takes place on liquid surfaces are chosen to give ideally homogeneous adsorbing surfaces so as to test quantitatively an equation previously put forward in Part I. Agreement is strict in many cases. Analysis of data on the adsorption of benzene, heptane, hexane, and pentane vapours on silica gel indicates that solid surfaces may behave as if they are homogeneous. D. F. J.

Solvent Extraction and Dewaxing.

1226. Additional features of Pure Oil's Smiths Bluff lube plant. Anon. *Oil Gas J.*, 16.3.50, **48** (45), 79.—A brief outline of major equipment involved in production of base stocks for the blending and compounding operations at Smiths Bluff refinery of Pure Oil Co., Texas, is given.

Units include a two-stage distillation plant, propane deasphalting, phenol extraction, solvent dewaxing with M.E.K., and contact filtration. G. A. C.

1227. Solubility diagrams for ternary and quaternary liquid systems. J. C. Smith. *Industr. Engng Chem.*, 1949, **41** (12), 2932–7.—Information on ternary and quaternary liquid systems is given in tabular form. The relevant literature was thoroughly checked. Limiting solubility curve and two tie-lines are available for each system included. Extensive bibliography is appended. R. G. T.

1228. Phase behaviour of a propane-topped crude oil system ; application to solvent extraction calculations. F. H. Poettmann and M. R. Dean. *Chem. Engng Prog.*, 1949, **45** (10), 636–43.—A graphical design procedure for carrying out solvent-extraction calculations on complex mixtures is presented, being similar to that of Moloney and Schubert for the solvent extraction of simple binary mixtures. The phase behaviour of a propane-topped crude-oil system is presented with an example using the graphical procedure described. J. G. H.

Cracking.

1229. Fluidization 1. H. A. Leniger and J. R. Jansen. *Ingenieur*, 9.12.49, **61** (49), Ch. 47.—The subject is dealt with in a number of sections, the first two of which are dealt with in detail in the above issue of the journal.

First, a definition of nomenclature describing the various types of catalyst beds and the conditions existing therein. A description of the fluidized condition and its characteristic properties is then given. The third section deals with pressure drop, and the fourth with mixing conditions in the fluidized bed. Then follows the description of the heat and material transfers occurring in a fluidized bed, and the paper concludes with a reference to the applications of fluidization.

The list of nomenclature, which embraces eleven different types or conditions relative to the subject, includes the following : fixed bed, moving bed, fluidized mass, fluidized bed, particulate fluidization, aggregative fluidization, quiescent fluidized bed, turbulent fluidized bed, dispersed suspension, channelling, and finally, slugging and pistoning.

Under the second heading, some space is devoted to the effect of gas velocity and particle size on the density of the bed, and the relative variations are shown graphically. The influence of particle shape on the viscosity of the bed is also demonstrated. R. R.

1230. Fluidization 2. H. A. Leniger and J. R. Jansen. *Ingenieur*, 17.2.50, **62** (11), Ch. 11.—The third section deals with the subject of pressure drop in fluid-catalyst systems. The derivations of a number of equations are given to illustrate quantitatively the influence of gas velocities, particle size, and friction coefficient on the pressure-loss factor.

These relationships are further demonstrated graphically on the basis of work carried out by several independent workers. A wide range of materials and particle forms are dealt with in the development of this section of the paper. R. R.

1231. Fluidization 3. H. A. Leniger and J. R. Jansen. *Ingenieur*, 17.3.50, **62** (11), Ch. 23.—The fourth section of the paper discusses the conditions of mixing on a fluidized bed. The findings of a number of investigators are reported, and some reference is made to the technique employed in the experimental work carried out.

The fifth and final section deals with the heat and material transfer in a fluidized bed. The influence of the physical properties of the materials involved, the working conditions prevailing in the system, and the design of the equipment are discussed in some detail. R. R.

1232. Effect of reactor temperature on product distribution and product quality in fluid catalytic cracking. C. R. Olsen and M. J. Sterba. *Chem. Engng Prog.*, 1949, **45** (11), 692–700.—The effect of reactor temperature on product distribution and product quality is becoming of importance with the extended use of fluid-catalytic-cracking plants. Details are presented of a series of tests run on a pilot plant at U.O.P at temp levels of 800° F and 950° F with synthetic catalyst. The general effect of increasing reactor temp at a given conversion is to produce less deposit on catalyst, less debutanized gasoline, and greater quantities of light hydrocarbon fractions having higher olefin contents. The liquid products contain higher concentrations of unsaturated components, and the clear O.N. of the gasoline is increased. J. G. H.

1233. Economics of thermal reforming. C. F. Feuchter. *Chem. Engng Prog.*, 1949, **45** (10), 644–8.—While octane number of straight-run gasoline can be increased by thermal reforming and by the addition of T.E.L., the normal practice is to use a combination of the two in order to meet a particular specification. The most economical combination of the two methods is discussed, together with the effects of product prices, T.E.L. cost, and O.N. specification on the economics of thermal reforming. J. G. H.

Polymerization.

1234. Propylene polymerization for motor-gasoline production. W. F. Deeter. *Oil Gas J.*, 23.3.50, **48** (46), 252.—The unit of the Richfield Oil Corporation for production of 350 b.d. of polymer at an average conversion of 80% and a catalyst life of about 35 gal of polymer per pound of catalyst is described.

The polymerization of propylene produces a gasoline with high octane values and sensitivity.

Economic advantages include upgrading of a fuel to gasoline; burning of additional fuel oil in those plants with a surplus; a saving in T.E.L., and an additional source of propane from the tail gas. G. A. C.

Chemical and Physical Refining.

1235. Filtration of refinery emulsions and separator sediment. E. Q. Camp and C. Phillips. *Oil Gas J.*, 23.3.50, **48** (46), 214.—An investigation to evaluate the continuous pre-coat filtrate process as a means of resolving refinery emulsions recovered from separators, upgrading the recovered oil, and improving quality of effluent water at Baytown refinery of Humble Oil and Refinery Co. is described.

Filter rates on mixtures prepared from fresh waste oil and emulsion samples were found to be higher than rates on several-days-old mixtures. Medium particle size precoat materials are the most satisfactory. Temperatures above 180° F had no appreciable effect of filter rate, but rates dropped rapidly with temperatures below 170° F.

Higher filter rates are obtained by increasing drum speed, but pre-coat life is considerably shortened.

Rates also increased rapidly as knife cut was increased from 0·0016 to 0·0025 in per revolution, and rate of increase of filter rate becomes less as pressure drop increases.

Results indicate that vacuum pre-coat filtration is a practical means of de-watering separator-bottom sediment. G. A. C.

1236. Hydrodesulphurization of gasoline fraction with tungsten–nickel sulphide catalyst. R. M. Cole and D. D. Davidson. *Industr. Engng Chem.*, 1949, **41** (12), 2711–15. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem., 115th meeting Amer. Chem. Soc., San Francisco.*)—Desulphurization of cat and thermally cracked

gasoline fraction by controlled hydrogenation over a commercial W–NiS cat is described. Cat activity, life, and regeneration are cited. Large-scale application has augmented aviation gasoline supplies. Pilot-plant and laboratory data are herein supplied.
R. G. T.

Special Processes.

1237. Some investigations on aromatization catalysts based on chromium and aluminium oxides. G. H. Visser. *Bull. Ass. franç. Tech. Pétrole*, 1950, (80), 3–15.—A lecture describing pre-war work at the Shell laboratory, Amsterdam. Various modifications of Al oxide and hydroxide are considered, and the importance of the past history of the cat source is shown. Preheating of Al_2O_3 cat strongly influences activity, *e.g.*, for conversion of *n*-butylene to *iso*butylene at 340° C max activity corresponds to a pre-heat temp of 700° C, this does not coincide with surface area, which falls linearly with increasing cat heating temp. Details are given of a reproducible laboratory method for the preparation of mixed Cr–Al cat, activity is assessed by aromatization of *n*-heptane at 465° C under standard conditions. Presence of Al_2O_3 improves cat power of Cr_2O_3, probably due to inhibition of crystallization of initially active amorphous Cr_2O_3. Mixed crystals of Al_2O_3/Cr_2O_3 (α forms) can occur in all proportions. Addition of K (as KOH or K_2CO_3) to give a ternary cat effects a marked improvement in activity, ratio of K/Cr atoms should be 12/100 irrespective of Cr_2O_3/Al_2O_3 ratio. Analogous but less-marked effects are obtained with Na and Li. Action of alkali metals may be due to inhibition of olefin reactions (isomerization and polymerization) which foul cat surface or to stabilization of the γ (active) form of Cr_2O_3.
V. B.

1238. Mass transfer in the flow of liquids through granular solids. M. Hobson and G. Thodos. *Chem. Engng Prog.*, 1949, **45** (8), 517–24.—An experimental technique for gas-film studies has been successfully adapted to the study of mass transfer from the surface of porous solids to liquid media flowing through the bed. Mass-transfer coefficients for the experimental systems investigated correlated as linear functions of the modified Reynolds number. *iso*Butyl alcohol–water and methyl ethyl ketone–water systems are investigated as examples, and from the data obtained a generalized mass-transfer factor for fluids is derived.
J. G. H.

1239. Two-phase fluid–solid flow. F. A. Zenz. *Industr. Engng Chem.*, 1949, **41** (12), 2801–6.—Experiments are reported which indicate the flow characteristics of solid particle–gas mixtures as a guide to more extensive work on pressure losses in stand-pipes, carrier-lines, and flowing fluid beds. Quantitative data are shown for the vertical and horizontal flow of three uniform particles and a material of 0·0066 in mean dia with five-fold variation in particle size. Experiments were performed in 1·75-in internal-dia Lucite tube with air as the fluid medium.
R. G. T.

1240. Heat transmission through fluidized beds of fine particles. M. Leva, M. Weintraub, and M. Grummer. *Chem. Engng Prog.*, 1949, **45** (9), 563–72.—An equation was derived for the calculation of heat-transfer coefficients through fluidized beds in terms of characteristic fluidization variables. Tubes of 2 and 4-in dia were used with round sand, sharp sand, and an iron Fischer–Tropsch catalyst in the particle-size range of 400 to 100 mesh. The effect upon rates of heat transfer of various bed, particle, fluid, tube, and fluidization variables was investigated, and the application of the equation to the design of reactors using the fluidization technique is discussed.
J. G. H.

1241. Influence of the catalyst on the formation of fatty acids during the oxidation of paraffin. H. Pardun and R. Kuchinka. *Erdöl u. Kohle*, 1950, **3**, 109–20.—Previously published theories regarding mechanism of liquid-phase cat oxidn of paraffin by air are reviewed, and a table is given showing the cat that had been reported, up to the end of 1944, for this reaction. Experimental details of the oxidn apparatus and procedure used are described; the raw material was a Fischer–Tropsch "gatsch" having b.p. (13 mm) 137–283° C, m.p. 37° C, and a mean mol size of C_{33}. The following metals, in the form of their stearates, were used as cat in amounts of 0·05–2%. Na,

Ca, Ce, Ti, Zr, Th, Sn, Pb, Mn, Fe, Co, and Ni. Oxidn was at 120° C using 5 l air/hr for 50 g charge, and was continued till a neut. No. of 50 was attained (9–35 hr). Analysis of products is given. Cat fall into three groups, those for which oxidn rate is ∝ concn (Ca, Th, Mn, Co, Ni), those for which low concn acts as a cat and high concn as an inhibitor (Na, Ce, Pb, Fe), and those for which no relationship between concn and reaction rate could be noted (Ti, Zr, Sn). Behaviour of the cat appears to be linked with its solubility in the paraffin. Tests with other oil-soluble Mn compounds showed cat activity to be dependent on Mn concn and independent of acid radical. With increasing oxidn rate the amount of more highly oxidized products formed (*e.g.*, hydroxy-acids) also increases. Binary cat in amount of 0·5% increased oxidn rate still further and tended to favour fatty acid formation in preference to that of hydroxy-acids; the best binary mixtures were those containing Mn (except Mn–Na). Tertiary mixtures were even more effective in both these respects, and a cat containing 90% Na, 5% Mn, and 5% Pb (as stearates) gave especially good results. Theories of cat action are discussed. Eighty-five references. V. B.

1242. Synthesis gas production; reactions of light hydrocarbons, steam and carbon dioxide in commercial equipment. E. L. Clarke, R. H. Kallenberger, R. Y. Browne, and J. R. Phillips. *Chem. Engng Prog.*, 1949, **45** (11), 651–4.—The production of synthesis gas suitable for the Fischer–Tropsch synthesis in a commercial-scale plant is described. Hydrogen and CO mixtures are produced by the reaction of natural gas with steam and CO_2. J. G. H.

Metering and Control.

1243. Gas-to-gas heat exchangers. R. W. New. *Mech. World*, 7.4.50, **127** (3299), 379.—The paper consists of a review of methods of heat transfer calculation. The use of different methods of calculating heat transfer for smaller types of gas-to-gas heat exchangers is illustrated. A. S.

Safety Precautions.

1244. Plant supervisors administer effective safety program. G. M. Dent. *Oil Gas J.*, 23.3.50, **48** (46), 246.—A programme has been devised by the Pan American Refining Corporation, Texas, to ensure that all workers are familiar with safety and fire-protection practices, based on a constant flow of written information to the supervisor.

Simulated fire drills are carried out for each major refining facility, thus the emergency organization is trained for the conditions likely to be met with at various locations. G. A. C.

PRODUCTS.

Chemistry and Physics.

1245. The effect of aromatic compounds on the vapour-phase oxidation of fuels. I. The effect of the vapour-phase oxidation of ethers. G. H. N. Chamberlain and A. D. Walsh. *Trans. Faraday Soc.*, 1949, **45**, 1032–43.—Experiments are reported on the effect of aromatic compounds on the vapour-phase oxidn of di-*iso*propyl ether in five broad temp–pressure regions: slow oxidn in the "high"-temp zone, ignition to hot flames in the "high"-temp zone, slow oxidn in the "low"-temp region, ignition to cool flames and to hot flames in the "low"-temp zone. Indications are that aromatics have an inhibiting effect in all five regions. A wide range of aromatics has been tested in the slow oxidn of di-*iso*propyl ether at 360° C and the efficacy of the inhibiting action correlated with the electronic properties of the benzene ring. Electron-releasing groups attached to the benzene ring enhance the inhibiting action of the compound with respect to benzene, and there is partial correlation with the direction of the dipole moment of the side chain. Aromatic inhibitors appear to react with radical chain carriers of more than one type. E. B.

1246. The effect of aromatic compounds on the vapour-phase oxidation of fuels. II. The anti-knock effect of aromatic compounds in engines. A. D. Walsh. *Trans. Faraday Soc.*, 1949, **45**, 1043–8.—A survey is made of the anti-knock effect of aromatic

compounds in I.C. engines and, with results described in Part I (see Abstract No. 1245), conclusions drawn as to the effect of structure of aromatic compounds on their anti-knock properties. Mono-substituted benzenes containing *o-p*-directing substituents are good anti-knocks, whilst *m*-directing substances are pro-knocks, relative to benzene. Aromatics exert their effect as undecomposed mols, and certain anomalies to the correlation between anti-knock effect and ring-electronic properties find explanation in the instability of longer side-chains, which should otherwise be more effective than shorter chains. Anti-knock effect of an aromatic compound can therefore be predicted. No aromatics with large side-chains or weakly bound side-chains are likely to be effective, because of the detachment of the side-chain in collision. Short side-chains must be such as to cause the greatest spread of the electron-cloud of the ring. Cool running conditions are desirable where the aromatic additive is being used near its temp limit of stability and, because of hotter running, response may be less in naphthenic than in paraffinic fuels. E. B.

1247. Stability of fuel oil/gas oil blends. D. G. Butlin. *J. Inst. Petrol.*, 1950, **36**, 43.—A technique is presented which affords a method for the selection of asphaltic fuel-oil and gas-oil components of blends which shall be stable in storage. The method is particularly applicable to the preparation of low-visc diesel-fuel blends, where a high degree of dilution of fuel with gas oil is necessary. The degree of compatibility of the two components is assessed by means of an index assigned to each oil, viz., the xylene equivalent of the fuel and the aniline point of the gas oil.

A laboratory method has been developed in line with practical conditions, so that actual sludge deposition can be related to the varying indices of the components used in such blends. The good correlation obtained on a large number of blends has inspired confidence in the validity of the principles underlying the method.

A. R. W. B.

1248. Stability of fuel oils in storage—effect of sulphur compounds. R. B. Thompson, L. W. Druge, and J. A. Chenicek. *Industr. Engng Chem.*, 1949, **41** (12) 2715–21. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem., 115th meeting Amer. Chem. Soc., San Francisco.*)—Investigation has been made of the effect of various S compounds found in fuel oils on storage stability of the oils. Sludge and soluble-gum measurements were made. It was found that sludge formation is promoted by free sulphur, disulphides and polysulphides, and thiophenol. Thiophenes and aliphatic mercaptan and sulphides show little effect. Explanation of the adverse effect of Doctor sweetening and the advantages of caustic methanol extraction is thereby made.

R. G. T.

1249. Effect of sulphur on combustion of leaded gasoline. H. K. Livingston, J. L. Hyde, and M. H. Campbell. *Industr. Engng Chem.*, 1949, **41** (12), 2722–6. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem., 115th meeting Amer. Chem. Soc., San Francisco.*)—Combination of sulphur compounds with T.E.L. in the cylinder produces a compound of reduced anti-knock activity. The reduction is greatest for more reactive S compound, *e.g.*, M_2S, SO_2, mercaptans, and disulphides. Unreactive S compounds only act by contributing SO_2 and SO_3 to the gaseous products. Variation of the C.F.R. engine spark advance, to produce a large change in pressure–temp–time relations in the fuel–air mixture was investigated. Engine conditions do not greatly affect the S–T.E.L. interaction. By analyses of combustion-chamber deposits from engines operating with leaded S-containing gasolines, deposit composition is shown to depend on S concn in gasoline. Lead oxysulphates are more common than lead oxide or sulphate. R. G. T.

1250. "Knock" tests using atmosphere in which nitrogen is replaced by argon and carbon dioxide. D. Downs and J. H. Pigneguy. *J. Inst. Petrol.*, 1949, **35**, 755.—The elimination of nitrogen to within 2% of the air charge (the nitrogen being replaced by argon) had no effect *per se* on the tendency to knock. The change which occurred in the H.U.C.R. was thought to be due to the lower heat capacity of argon. A gas mixture of argon, carbon dioxide, and oxygen having the same specific heat and yielding the same power output in the engine as normal atmospheric air showed very

similar knock tendency to normal air, indicating that nitrogen had no effect on knocking. The substitution of argon for nitrogen appeared to reduce the effectiveness of lead in suppressing knock. A. R. W. B.

1251. The importance of surface oxide films in the friction and lubrication of metals. I. The dry friction of surfaces freshly exposed to air. E. D. Tingle. *Trans. Faraday Soc.*, 1950, **46**, 93–7; **II. The formation of lubricating films on metal surfaces,** *ibid.*, 97–102.—A surface layer of oxide, formed within a few seconds of a metal being cut, markedly reduces friction; subsequent growth of oxide film produces less effect. Effective lubrication of metal surfaces by fatty acid solutions (in liq paraffin) depends upon presence of an oxide film capable of reacting with the acid. Metals are divided into three groups, explaining their behaviour in this respect: (i) metals forming a permeable oxide layer, reacting to form multi-molecular soap films (friction coeff (μ) approx 0·1), *e.g.*, Cu, Cd, Mg, Zn; (ii) metals whose oxides form a compact skin which, when lubricated with a fatty acid solution causes stick-slip sliding, possibly a monomolecular soap layer is formed (μ approx 0·3), *e.g.*, Al and, probably, Cr and Ni; and (iii) metals forming little or no film (μ approx 0·6), *e.g.*, Pt, Au, Ag. The Bowden–Leben apparatus was used, and a new " cutting " technique is described and illustrated. E. B.

1252. Azeotrope formation between thiols and hydrocarbons. R. L. Denyer, F. A. Fidler, and R. A. Lowry. *Industr. Engng Chem.*, 1949, **41** (12), 2727–37. (*Symposium on Sulphur in Petroleum. Div of Pet. Chem., 115th meeting, Amer. Chem. Soc., San Francisco.*)—Fifty-five azeotropes formed between C_2, C_3, and C_4, thiols and twenty-eight different hydrocarbons have been determined and their physical properties measured. No azeotropes were found with benzene. Results are correlated and shown to agree with recent equations by Skolnik to cover azeotropes of benzene with hydrocarbons. A straight-line relation is found between the b.p. of the hydrocarbon and the mol·% of thiol in the azeotrope. Seventeen azeotropes between these thiols and other hydrocarbons, and between paraffins and other thiols, have thus been predicted. R. G. T.

1253. Thermodynamic properties of nitroparaffins. D. E. Holcomb and C. L. Dorsey, Jr. *Industr. Engng Chem.*, 1949, **41** (12), 2788–92.—Experimental determinations of heats of combustion of six mononitroparaffins and four polynitroparaffins were made with 2 parts in 1000 accuracy. Standard heats of formation were calc. Several latent heats of vaporization were estimated to 1% accuracy from v.p. measurements. Heats of combustion are shown to be linear function of the O_2 balances of the mols; an equation is derived relating these two variables with an average of about 2% of experimental values. The semi-empirical correlations of Kharasch and Andersen, Beyer and Watson between heats of combustion and structure apply to the nitroparaffin series to 1%. R. G. T.

1254. Chlorination of saturated hydrocarbons. W. Hirschkind. *Industr. Engng Chem.*, 1949, **41** (12), 2749–52.—Chlorination of CH_4 and homologues is much more difficult than of unsaturates (C_2H_4 and C_2H_6) because of the need to activate the Cl_2 by photochemical or thermal means. Both are used commercially. Photochemical activation is influenced by traces of impurities causing inhibition of reaction by chain termination. Thermal activation requires 250° C for starting and close temp control. A process for manufacturing all chlorinated methanes by continuous chlorination of CH_4 is described. New methods are described for manufacture of perchloroethylene and hexachloroethane. R. G. T.

1255. Branched chain hydrocarbons, their synthesis and reactions. W. J. Hickinbottom. *J. Inst. Petrol.*, 1950, **36**, 67.—A summary of work intended to develop methods for the synthesis of hydrocarbons with a repeating pattern of quaternary carbon atoms and side chains. A. R. W. B.

1256. The synthesis of 2 : 3 : 5-trimethylhexane and of 2 : 4 : 6-trimethylheptane. H. J. Shine and E. E. Turner. *J. Inst. Petrol.*, 1950, **36**, 70.—Three separate schemes have been explored for the synthesis of each of these hydrocarbons. A. R. W. B.

1257. Some general considerations of hydrocarbon synthesis. C. R. Porter. *J. Inst. Petrol.*, 1950, **36**, 61.—Some guiding principles of hydrocarbon synthesis, aimed at obtaining substances in as pure a condition as possible, and by methods which leave no reasonable doubt that they really are the substances alleged, are discussed.

A. R. W. B.

1258. A new iron carbide in hydrocarbon syntheses catalysts. H. C. Eckstrom and W. A. Adcock. *J. Amer. chem. Soc.*, 1950, **72**, 1042–3.—An iron catalyst, prepared from reduced promoted mill scale, and containing potassium chromate as promoter, was subjected to X-ray examination during the course of a fluidized synthesis run of hydrogen and carbon monoxide, when the appearance of a new iron carbide was observed. This carbide ultimately constituted approx 90% of the total catalyst, and chemical examination gave an iron-to-carbon ratio of 0·96, showing the new phase to be equivalent to " FeC." W. H. A.

1259. Purification of and the determination of the physical properties of hydrocarbons. R. A. Lowry. *J. Inst. Petrol.*, 1950, **36**, 80.—Methods of purification are briefly discussed, together with the determination of physical properties of hydrocarbons.

A. R. W. B.

1260. Determination of saturated and aromatic constituents in spindle distillates and derived products by adsorption fractionation. G. H. Beaven, L. F. Foster, and C. N. Thompson. *J. Inst. Petrol.*, 1950, **36**, 89.—A method has been developed for the quantitative separation, on an analytical or preparative scale, of the aromatic and saturated compounds in petroleum products in the spindle-oil viscosity range, irrespective of the amounts present. The separation is based on the relative adsorption affinities of the oil components for silica gel. This method has found satisfactory application in the analysis of low-aromaticity oils for which other methods are less suitable.

By using a number of different eluants, the aromatic fraction may be fractionated further. A. R. W. B.

1261. Bromination methods of measuring unsaturation in motor spirit—a critical survey. G. W. Wilson. *J. Inst. Petrol.*, 1950, **36**, 25.—A historical treatment has been applied to the evolution of methods employed to measure the degree of unsaturation in hydrocarbon oils. An original application of pyridine sulphate–bromide to the estimation of the degree of unsaturation in motor spirit has been elaborated, and the use of Kaufmann's reagent for a similar purpose fully investigated. In connexion with the latter the influence of peroxides on the value of bromine numbers has been noted. A short account of the mechanism involved in halogenation by means of Kaufmann's reagent is given, the interpretations of the reactions being based on recent work on the chemical kinetics of organic reactions in liquid systems. A. R. W. B.

1262. Physical data on some organic compounds. R. R. Dreisbach and R. A. Martin. *Industr. Engng Chem.*, 1949, **41** (12), 2875–8.—F.p., densities at 20° and 25° C, and refractive indexes at 20° and 25° C, the C value of the Eykman equation, density at 25° C calc from C value and n_D^{25}, the A and B values of the Antoine equation, A* and B* values of the Dreisbach–Spencer orthobaric vapour–density equation, a and b parameters of the law of rectilinear diameters, b.p., and dt/dp values at 760 m, and relation between b.p. and pressure are tabulated for ninety-six organic compounds.

R. G. T.

1263. Vapour pressure temperature data on some organic compounds. R. R. Dreisbach and S. A. Shrader. *Industr. Engng Chem.*, 1949, **41** (12), 2879–80.—The determined b.p.s at 760 mm pressure and seven lower pressures are listed for various organics. The infinite points of twenty-three cox chart families are listed. R. G. T.

1264. High pressure vapour liquid equilibria; activity coefficients for ideal systems. K. A. Smith and K. M. Watson. *Chem. Engng Prog.*, 1949, **45** (8), 494–507.—For application to ideal systems of components having no chemical dissimilarity, generalized correlations are developed for vapour-phase and liquid-phase activity coefficients

which express deviations from the laws of ideal solutions in two-phase mixtures at high pressures. Activity coefficients are used in conjunction with thermodynamic equilibrium constants derived from modified definitions of the standard states of unit activity proposed by Gamson and Watson. These constants are developed for wider ranges of conditions, and require less correction than those previously available. The accuracy of consistent correlations of equilibrium constants and activity coefficients showed mean deviations from experimental data for paraffin hydrocarbons of 15% for 184 comparisons, while the use of equilibrium coefficients alone showed a mean error of 216%. Vapour and liquid compositions, dew point and bubble points are found to be calculated in this manner by straightforward and reproducible methods with reasonable accuracy. Other applications of the method are also indicated.

J. G. H.

1265. Solubility and phase relationships; high molecular weight aliphatic compounds in liquid propane. R. Bosgash and A. N. Hixon. *Chem. Engng Prog.*, 1949, **45** (10), 592–601.—The application of propane to the separation of high-mol.-wt. compounds other than those of petroleum origin has been recently developed. The correlation between effective mol. wt. and critical solution temp previously presented for fatty acids and their esters of mono- and polyhydric alcohols is now extended to myristic and lauric acids and their triglyceride esters. An exploratory survey is also made of the effect of different functional groups, using typical amides, amines, and nitriles.

J. G. H.

1266. Action of lithium aluminium hydride on organic disulphides. R. C. Arnold, A. P. Lien, and R. M. Alm. *J. Amer. chem. Soc.*, 1950, **72**, 731–3.—In an ether-type solvent lithium aluminium hydride reduces disulphide linkages in organic molecules. Reduction involves stoichiometric liberation of hydrogen from the hydride, and rupture of the sulphur–sulphur linkage forming a lithium–aluminium complex from which mercaptans are obtained by hydrolysis with dilute acid. Measurement of the liberated hydrogen provides a possible method for the quantitative determination of disulphides.

W. H. A.

1267. Thermodynamic properties of some sulphur compounds. G. M. Barrow and K. S. Pitzer. *Industr. Engng Chem.*, 1949, **41** (12), 2737–40. (*Symposium on Sulphur in Petroleum. Div of Pet. Chem., 115th meeting Amer. Chem. Soc., San Francisco.*)—A summary is made of available and readily calculated thermodynamic properties of mercaptans, sulphides, disulphides, sulphoxides, sulphones, S, H_2S, SO_2, and SO_3. Data for methyl and ethyl compounds are given in each case. Application to larger radicals is discussed. Entropies and heat capacities are calc by statistical methods where possible, or by summation of additive data for the molecular parts involved. Heats of formation are largely from Thomsen and found to be consistent with the directions of chemical reaction where known. The need for thermochemical data of organic sulphur compounds is stressed.

R. G. T.

1268. Induced fibration of suspensions. W. M. Winslow. *J. appl. Phys.*, 1949, **20** (12), 1137–40.—Previous work has shown that certain kinds of particles suspended in low-visc oils tend to form an oil-occluding fibrous mass when acted on by an electric field. The fibres form in the general direction of the field and in such a manner that the electrodes are mechanically linked together. The effect is intrinsically reversible under the action of shear. The method of preparation of conc fluids capable of reversible shear resistance up to several hundred g/cm^2 is described. Dynamic induced shear resistance or the corresponding induced bulk visc is shown to be a parabolic function of the field strength. Properties of the fluids are discussed with regard to the mechanism of induced vibration, its application in slip clutches and other hydraulic devices, and some of the factors required for best results.

D. F. J.

1269. Method for the instantaneous measurement of velocity and temperature in high speed air flow. D. G. Marlow, C. R. Nisewanger, and W. M. Cady. *J. appl. Phys.*, 1949, **20** (8), 771–6.—A beam of ultrasonic sound waves is projected across the air stream the temp and velocity of which is required. From the known ultrasonic frequency and the measured wavelength the temp may be determined; and from the

slope of the beam boundary an approx Mach No. may be obtained. The method is applicable to either steady-flow or transient-flow problems. D. F. J.

1270. The anomalous reactions of Grignard reagents (I). H. J. Shine and E. E. Turner. *J. Inst. Petrol.*, 1950, **36**, 73.—The reactions of Grignard reagents with carbonyl compounds have been investigated with the object of obtaining an understanding of anomalies observed. A. R. W. B.

1271. Note on the rheological properties of elasto-plastic materials. K. Goldsmith. *Brit. J. Appl. Phys.*, Apr. 1950, **1** (4), 107.—It is shown that the flow properties of some elasto-plastic (generalized Bingham) materials, for example, soap gels and chalk pastes, can be expressed by an empirical equation if the materials are subjected to a varying stress which is dependent on the shear.

Three constants, which can be derived from this equation, characterize the flow properties. R. V. W.

Analysis and Testing.

1272. Chromatography of petroleum hydrocarbons. W. H. Smit. *Faraday Soc. Discussions*, 1949, **7**, 248–55.—A review of the applications of chromatography to the separation of pet hydrocarbons is given. Following on work using mixtures of pure hydrocarbons a lub oil was separated into fractions by percolating a 10% solution in pentane through a 300-cm column of 200-mesh silica gel. Wt ratio gel/oil was 10/1. Development with pentane produced a fraction containing paraffins and naphthenes (mainly naphthenes) of n_D^{20} 1·453–1·530, aromatics (mainly dicyclic) with n_D^{20} 1·510–1·597 were recovered on development with CCl_4, and polycyclic aromatics of n_D^{20} 1·611–1·644 with $CHCl_3$. About 10% of the oil remained in the column and was eluted by ether, which on evaporatien left a sticky brown mass with a high S content. A second example illustrates the separation, by the use of pentane, of two type-fractions containing mono- and di-cyclic naphthenes respectively. Comparison of the separations achieved with a hydrogenated oil (mainly naphthenes) by thermal diffusion (240 hr) and percolation (8 hr) demonstrated the superiority of the latter. E. B.

1273. Chromatographic fractionation of black oils. A. S. C. Lawrence and D. Barby. *Faraday Soc. Discussions*, 1949, **7**, 255–8, 327.—Preliminary attempts at separating black oils into fractions of different types are recorded. Separation has been achieved into white oil (containing any wax present), pale yellow, and highly coloured fractions having progressively increasing *n* and dispersions. Resinous substances containing O_2 are strongly adsorbed by alumina and powdered coke. Ultimate analyses show presence of O_2 in all fractions, and S in the more highly coloured fractions. Indications are that in the latter oxygen is present in polar form. E. B.

1274. Separations using zeolitic materials. R. M. Barrer. *Faraday Soc. Discussions*, 1949, **7**, 135–41.—Properties of natural zeolites as mol sieves and sorbents are reviewed. Zeolites having a robust three-dimensional network fall into three classes—class I (*e.g.*, chabazite) do not sorb *iso*butane (and other *iso*-paraffins), sorb C_3H_8 and other *n*-paraffins slowly at room temp or above and C_2H_6,CH_4 and mols of smaller cross-section rapidly; class II (mordenite) does not sorb *n*- or *iso*-paraffins, sorbs C_2H_6,CH_4 slowly and N_2 and smaller mols rapidly; class III (Ca and Ba mordenites) sorb C_2H_6 and CH_4 to a negligible extent and N_2 rapidly. Decisive factor governing sorption is the shape rather than the mol vol of the sorbate. References are given to reported examples of separations, and mols occluded or excluded by the three above classes of mol sieve are listed. Other aspects covered are artificial modification of sorbents, effect of temp on selective sorption of different gases, activation and poisoning of zeolites. E. B.

1275. Significance of properties of petroleum products. IX. Impurities in petroleum products. V. Biske. *I.P. Review*, 1950, **4**, 82.—Acidity, ash, sediment, and water are considered to be impurities when present in oils. Acidity may be "organic" or "inorganic," and is expressed in "mgKOH/g." Various methods of determination are described, all based upon the titration principle. Its determination is important because acidity leads to corrosion. Ash is essentially the non-volatile portion. Thus,

all inorganic matter is not necessarily determined by the combustion method. Sometimes, the material is sulphated before burning. The sediment is the material present in a petroleum product, insoluble in the oil or in a solvent like benzene. It may be determined by filtration or extraction. Sediment is of particular interest in the case of fuel oils. Water-content determinations are generally carried out by a distillation procedure. Chemical methods are also used. Both sediment and water may be determined by a procedure known as the " B.S. & W " method, a centrifuging technique in warm benzol solution. R. H.

1276. Calibration of I.P. diesel reference fuels. Anon. *J. Inst. Petrol.*, 1949, **35**, 791.—Results of a re-check of the calibrations of these fuels are presented. A. R. W. B.

1277. Sulphur (corrosive)–copper strip tests, I.P.-64/49. *J. Inst. Petrol.*, 1950, **36**, 56.—An amendment to one paragraph of the text of this method in the Tenth (1949) Edition of " Standard Methods for Testing Petroleum and Its Products " is announced. A. R. W. B.

1278. Evaluation of gassing tendencies of insulating oils : apparatus, procedure, and effect of experimental variables. G. H. Beaven, J. A. Cockburn, and C. N. Thompson. *J. Inst. Petrol.*, 1949, **35**, 735.—Previous work on the subject is summarized, and the observed phenomena are discussed. Experimental techniques are outlined. A convenient numerical form of expressing the results of gassing tests has been introduced. The effects of : (*a*) random supply-voltage variations ; (*b*) working voltage ; (*c*) temperature ; (*d*) inner electrode dimensions ; (*e*) position of oil-gas interface, and (*f*) the nature of the gas phase on the results of gassing tests have been determined.

Simple electrostatic theory has been used to calculate the radial variation of voltage gradient in the apparatus, and previous explanations of the gassing process in hydrocarbon insulating oils have been applied to the results presented. A. R. W. B.

1279. A pendent-drop apparatus for surface and interfacial tensions. H. W. Douglas. *J. sci. Instrum.*, 1950, **27**, 67.—Constructional details are given of a two-part thermostat and syringe holder which has proved convenient for use with a Pyrex syringe and tip and a rectangular optical cell employed in the measurement, by the pendent-drop method, of the boundary tension of liquid/gas and liquid/liquid systems. A brief account is also given of the optical system employed, and of the method by which the tensions have been evaluated. A table is given comparing observed representative tensions for hydrocarbon materials with corresponding values from the literature. The agreement between them is very satisfactory, and suggests that the pendent-drop method deserves to be more widely used as a convenient, accurate, and fundamental method for the evaluation of surface and interfacial tensions, and of related phenomena. C. N. T.

1280. Selective adsorption of hydrocarbons. I. G. Spengler and K. Krenkler. *Erdöl u. Kohle.*, 1950, **3**, 120–4.—Equilibrium between adsorbent and adsorbate is rapidly attained by adding all of the former in powder form to a solution of the latter and shaking. As solvent a low-boiling (40–48° C), oleum-refined pet spirit is preferred. Examination of adsorbents showed their general efficacy to be in the decreasing order silica gel–activated charcoal–alumina, but adsorbents exhibit a certain degree of specificity, thus members of a homologous series are better separated by activated charcoal, whilst silica gel exhibits greater selectivity for unsaturated compounds. Study of the effect of the solvent showed that in the case of silica gel adsorption increased with increasing mol. wt. of the solvent, but that the reverse was the case for activated charcoal. This may be due to the difference between the hydrophilic character of silica gel and the hydrophobic nature of activated charcoal. Effect of temp was examined in range −78° to +20° C, adsorption increased linearly with fall of temp, ratio of adsorption at lower temp to that at higher is characteristic of the adsorbent, and varied from 1·55 for silica gel to 3 for alumina. V. B.

1281. Phase equilibria in hydrocarbon systems—phase behaviour in the methane–*n*-butane decane system at 160° F. H. H. Reamer, J. M. Fiskin, and B. M. Sage. *Industr. Engng Chem.*, 1949, **41** (12), 2871–5.—Experiments are described by which

phase-equilibrium data for methane–*n*-butane–decane system were obtained at 160° F on 1000–4000 p.s.i. Phase composition and relation between equilibrium constant and pressure are evaluated. Graphical and tabular results are included. R. G. T.

1282. Influence of metals on the friction value of lubricants. H. Jentzsch. *Erdöl u. Kohle*, 1950, **3**, 124–7.—Description is given of the Jentzsch friction machine, in which a 2-h.p. motor rotates a steel roller against a loaded test-friction block. As metal and lubricant for standard conditions, bronze and a fatty oil are used at 800 r.p.m. and 10 kg/cm² loading. Temp readings are taken of the test-block bearing-surface and of the oil and the power consumption of the motor is recorded. Test duration is 2 hr. Typical curves are given showing use of the machine; among the possible applications is the determination of the effect of changes in the metal on the lubricating property of diesel fuels, a factor of importance in the design of fuel-injector pumps for C.I. engines. In many cases lubricating failures are attributed to the oil, whereas they are in fact due to use of unsuitable bearing metal. V. B.

Gas.

1283. Predicting burner performance with interchanged fuel gases. J. Grumer. *Industr. Engng Chem.*, 1949, **41** (12), 2756–61.—Information on flame stabilization and air entrainment is combined into relationships predicting the performance of all burners in a community when fuel gases are changed. No. of burners or individual characteristics are irrelevant. Performance is represented by a point in a diagonal of boundary-velocity gradients at flame port versus gas–air ratio. Previously derived theoretical equations enable calc of burner performance with a new fuel. If this falls within the stable flame region of the new fuel, interchangeability is possible.
R. G. T.

Engine Fuels.

1284. Field experience with high sulfur diesel fuels. R. J. Furstoss. *S.A.E. Trans.*, Oct. 1949, **3**, 609–15, 638.—Data are presented on the operation of small-bore, medium-speed diesel engines using fuel with a sulphur content in excess of 0·5%. Extreme cylinder and ring wear were encountered, together with abnormal engine deposits. It was found that close control of min temp, the use of corrosion-resistant materials, and the hard chrome plating of the top ring were effective in minimizing cylinder wear, while the use of improved lubricants practically eliminated the engine deposit and still further reduced cylinder wear. J. G. H.

1285. Some factors in gasoline economy. W. S. James. *S.A.E. Trans.*, July 1949, **3**, 516–30.—A general survey is presented of means of obtaining more m.p.g. Max values for this factor are evolved, and the effects of traffic stoplights, car design, decrease in weight and increase in C.R. are discussed. J. G. H.

1286. Factors affecting octane-number-requirement. H. J. Gibson. *S.A.E. Trans.*, Oct. 1949, **3**, 557–70.—The wide variations in O.N. requirements are remarked, and reasons for these variations are discussed. These include effect of atmospheric variables, combustion-chamber deposits, lubricating oils, base fuel composition, and torque converters. It is suggested that careful attention to engine adjustments can go far towards eliminating variations from engine to engine, and will enable test-car data to be made more consistent and reproducible. J. G. H.

1287. Measurement of surface temperature of evaporating water drops. J. C. Johnson. *J. appl. Phys.*, 1950, **21** (1), 22–3.—The study of evaporation processes is important in explaining and predicting the behaviour of atomized fuels. Water drops have been suspended from a small thermocouple in a chamber in which the humidity and temp are controlled, and surface temp of the drops have been measured directly. The results are in agreement with the theory of Fuchs, which states that the temp is proportional to the difference between the ambient and saturated vapour density of the drop. D. F. J.

Gas Oil and Fuel Oil.

1288. One oil system feeds 278 burners. J. W. Schulz. *Fuel Oil & Oil Heat.* Mar. 1950, **9** (3), 63.—The house-to-house oil piping at New Haven, Conn. housing project is described. 276 small pressure burners each firing a separate furnace-duct system at 0·85 g.p.h. receive oil from two side-by-side 10,000-gal tanks. Two larger pressure burners, each firing a separate boiler–radiator system at 5·5 g.p.h., receive oil from the same tanks.

The distribution system is discussed, and a diagram of the general lay-out is presented. Overflow taps are utilized to provide proper levels of oil for each group of buildings. Six circuits distribute oil to the 276 burners. Each circuit operates under different static-head pressures. There is a vented overflow trap at the oil-output end of the distribution piping for each group of same-level buildings. This trap sets the oil level for a particular group of buildings. Sight-glass flow-indicators, in the return lines, permit easy check-up on the adjustment of the key-operated valves. These indicators are grouped in the pump-room. D. K.

Lubricants.

1289. Motor oil consumption characteristics. C. W. Georgi. *S.A.E. Trans.*, July 1949, **3**, 431–43.—The factors determining the rate of oil consumption in an engine are itemized, and the interrelation of these properties having the greatest effect on consumption tendencies, volatility, viscosity, and V.I. are discussed in detail with the results of laboratory and road tests. These indicate that oils having low volatility, within defined limits, high viscosity and high V.I. tend to possess the lowest consumption characteristics. Appendices deal with laboratory engine-test procedure and with a rotary thin-film viscometer used for determining relative viscosities of oils at high rates of shear. J. G. H.

1290. Polymers and lubrication. W. Davey. *Scientific Lubrication*, Mar. 1950, **2**, 2–6.—The theory of polymer formation, the types of polymers existing, and products derived from natural polymers are described. The applications of polymerized ethylene, poly*iso*butylene, and polyvinyl chloride and acetate are discussed, and the use of polymers as pour-point depressants and V.I. improvers is remarked, together with the employment of phenolic resins as gear and bearing materials. J. G. H.

1291. Value of strainers in lubrication systems. Anon. *Scientific Lubrication*, Feb. 1950, **2**, 6–8.—The necessity for filtration of lubricants in service is remarked, and the by-pass, fuel-flow, and strainer methods are briefly described. The types of strainer available are enumerated, and edge-type strainers, wire-wound elements, scraper blades, and reverse-flow strainers are discussed. J. G. H.

1291a. Tracing causes of sludges and deposits in lubricating systems by use of modern microchemical methods. J. S. Wiberley and J. B. Rather. *Lubr. Engng*, Feb. 1950, **6**, 11–15.—The value of microchemical methods in the analysis of small samples of sludges and deposits taken from lubricating systems is emphasized, and a general approach is outlined covering microscopic examination, determination of ash, determination of solubilities in petroleum ether and chloroform, and qualitative organic analysis. The causes of deposit formation and the interpretation of results are discussed, and some typical examples of the application of microchemical methods are presented together with a bibliography (twenty-nine references). J. G. H.

1292. Effectiveness of mist lubricating and cooling systems. H. J. Chamberland. *Lubr. Engng*, Feb. 1950, **6**, 21.—The importance of directing lubricants, cutting, and grinding compounds at the point of work and tool contact is stressed, and the advantages accruing from the use of oil-mist processes are remarked. Operating results are presented of the application of mist lubrication to sawbands, and of the employment of a mist-cooling system in precision surface grinding. J. G. H.

1293. Special heavy-duty type engine oils. J. A. Edgar, J. M. Plantfeber, and R. F. Bergstrom. *S.A.E. Trans.*, July 1949, **3**, 381–90.—The results and limitations of the

use of heavy-duty oils containing metallic soaps in diesel engines are noted, and the properties of a new compounded special heavy-duty type of oil are enumerated. These include increased detergent qualities, oxidation stability, stability to high piston temperatures, and high anti-wear properties. Corrosive wear and fouling, whether due to operating conditions or the use of sulphurous fuel, are largely corrected by the use of the new type oil. Marked reduction of corrosive cylinder wear, however, results in substantial consumption of the additive, and, when continued service results in the development of a strong acid number, the anti-corrosive property disappears.
J. G. H.

1294. Synthetic lubricating oils. A. E. Williams. *Scientific Lubrication*, Feb. 1950, **2**, 2–5.—The processes employed in production of synthetic oils from coal are noted, and the Fischer–Tropsch process is described in some detail as providing in the form of olefins suitable raw material for lubricating-oil manufacture. The catalysts and operations employed in the polymerization of olefins are noted, and the properties of the lubricant so obtained are enumerated. Details of the hydrogenation process, suggested as the most promising refinery treatment, are also presented. J. G. H.

1295. N.C.A. friction studies of lubrication at high velocities. E. E. Bisson and R. L. Johnson. *Lubr. Engng*, Feb. 1950, **6**, 16–20.—Data are presented on kinetic friction experiments conducted on steel specimens with various lubricant films over a range of sliding velocities between 50 and 8000 f.p.m. and loads from 269 to 1543 g. The lubricant films employed included solid surface films, iron oxides, supplemental lubricants, molybdenum disulphide, graphite, and lubricants containing E.P. agents, in this case sulphur. Kinetic friction of dry surfaces and of boundary lubricated surfaces was found to decrease with increased sliding velocity. The formation of Fe_3O_4 on sliding surfaces was found to be desirable, that of Fe_2O_3 was not so generally beneficial over the entire range of sliding velocities. A solid film of molybdenum disulphide proved most effective in the reduction of friction at high sliding velocities.
J. G. H.

1296. Effect of surface roughness on rolling friction. J. J. Bikerman. *J. appl. Phys.*, 1949, **20** (10), 971–5.—Experiments have been conducted to determine the min tilt at which bearing balls roll down inclined plates of variable roughness. This minimum tilt is greater the rougher the surface. The results are compared quantitatively with an idealized theory attributing rolling friction to surface roughness, good agreement being obtained with the results for the rougher surfaces. Elastic deformation of the contact surfaces was negligible for the rougher surfaces. This would not be the case if the balls were loaded. The resistance to rolling would then not be caused by the original roughness.
D. F. J.

Bitumen, Asphalt, and Tar.

1297. Bitumen horizons. A. W. Jarman. *J. Inst. Petrol.*, 1950, **36**, 2.—A review of current U.K. practice in the utilization of bitumen, including its use for road and airfield surfacing, for hydraulic engineering, and for a wide range of industrial purposes. The properties of bitumen are mentioned, and indications are given as to the direction in which further modification of these is considered desirable with a view to extending the scope of bitumen utilization.
A. R. W. B.

1298. Use and abuse of seal coats. C. V. Kiefer. *Rds and Streets*, Feb. 1950, **93** (2), 88.—The author gives fully documented reasons for the application of seal coats, together with indications as to when "sealing" should and should not be done. The various approaches to assessing the amount of binder are described. The importance of deciding the viscosity and nature of the binder to be applied is stressed. Full details of the application of seal coats are given.
R. H.

1299. Triaxial testing: the adaptation and application to highway materials. Part 1. Method of testing disturbed soils and flexible base materials. C. McDowell. *Rds and Streets*, Feb. 1950, **93** (2), 63.—The various factors believed to have a major influence upon the strengths of subgrade and flexible base materials have been studied upon

the basis of field and laboratory tests. Such factors are always present, irrespective of the method of evaluation. A triaxial test method has been devised, and is described; this method evaluates properly these major influences. Design of flexible pavements based upon these results will be described in a later article. R. H.

1300. Colloidal structure of asphalt. H. Eilers. *J. Phys. & Colloid Chem.*, 1949, **53** (8), 1195–1211.—A survey is made of the interrelation between the composition and the colloidal structure of asphalts. Asphalts are classified into three rheological–colloidal types.

(1) Asphalts with purely viscous flow. That is, in which the rate of shear at constant stress is independent of time, the deformation per unit of time is proportional to the shearing stress, and there is no elastic recovery. These are either homogeneous, asphaltene-free substances, or they contain well-peptized asphaltenes of low voluminosity and consequently poor deformability.

(2) Sol-type asphalts in which viscous flow is accompanied by an elastic effect. This manifests itself under constant shearing stress in an initially decreasing rate of deformation and, after the stress has been removed, in a partial elastic recovery. These asphalts contain free miscelles which at room temp consist of asphaltenes and the most polar components of the maltenes.

(3) Gel-type asphalts. The elastic recovery after slight deformations under a small stress is almost complete. When the shearing stress exceeds a certain value, the yield value, the recovery becomes incomplete. The rate of deformation under constant stress may increase with time, but after removal of the stress the original value of the resistance to shear is gradually recovered. These gel-type asphalts contain an insufficient amount of the adsorbable maltene components to peptize completely the high percentage of asphaltenes, so that the miscelles coagulate and build up a continuous gel structure in the material. On heating, this skeleton and even the miscelles disintegrate, and its reconstruction on cooling is only slow, causing a definite age hardening. D. F. J.

Special Hydrocarbon Products.

1301. Ethylphosphoric esters as insecticides: old and new methods of preparation. L. Malatesta. *Chim. e Industria*, 1949, **21** (11), 338.—The mixture of ethyl esters of phosphoric and polyphosphoric acids, used by the Germans during the war as substitute insecticides for nicotine, has as its active constituent tetra-ethylpyrophosphate and not hexa-ethyl tetraphosphate as previously claimed. The reactions by which these compounds are prepared industrially are described. The possibility presented by Balarev's method is pointed out, of synthesizing them by the reaction of ethyl metaphosphate and diethyl ether at 100–130° C. D. H. McL.

1302. Evaluation of new fungicides. S. M. Peck. *Chem. Prod.*, Apr. 1950, **13** (5), 176.—An ideal fungicide would be one which is not primarily irritating, which has a low sensitization index *per se*, which suppresses the growth of the fungi, and which, at the interphase between fungicidal and fungistatic activity, does not stimulate the pathogenic organisms to produce antigens. A method is described which claims to evaluate the latter. It is based on the study of the effects of addition of fungicides on the production of trichophytin. A series is given of experiments which are typical examples of the evaluation by the above method of some of the old and well-known fungicides, as well as some of the newer ones. A. S.

1303. Manufacture of carbon disulphide from methane and sulphur. U. Sbovgi and E. Giovannini. *Chim. e Industria*, 1949, **31** (11), 391.—A method is described for the industrial manufacture of carbon disulphide from methane and sulphur in the vapour phase, in the presence of tungsten or molybdenum catalysts at 600°–900°. At the higher temp range, H_2 rather than H_2S is obtained as a by-product. D. H. McL.

1304. Synthesis of dicarboxylic acids from acetylene and carbon monoxide. G. Natta and P. Pino. *Chim. e Industria*, 1949, **31** (7), 245.—The reaction between acetylene and carbon monoxide in presence of methyl alcohol has been studied at higher pressures than those previously employed (200–250 atm), using cobalt and nickel catalysts. Esters of fumaric and methyl succinic acid were formed. D. H. McL.

Derived Chemical Products.

1305. Chemicals from hydrocarbon synthesis. T. Q. Eliot, C. S. Goddin, Jr., and B. S. Pace. *Chem. Engng Prog.*, 1949, **45** (8), 532–6.—The modified Fischer-Tropsch synthesis process as employed in the U.S. produces, in addition to liquid hydrocarbons, significant amounts of aliphatic oxygenated compounds as by-products. The amount and distribution of these compounds produced by a representative hydrocarbon synthesis plant are described, and problems involved in the separation and refining of these materials into marketable products are considered. J. G. H.

Coal, Shale, and Peat.

1306. Oil shale in Brazil. A. J. Kraemer. *U.S. Bur. Mines Rep. Invest., No.* 4655, Feb. 1950.—The oil-shale deposits of Brazil, in particular the concessions of Companhia Nacional de Oleos Mineraes, in the Paraiba River Valley of San Paulo state, are described. This concession is one of the most promising for large-scale utilization for the manufacture of liquid fuels and other products of oil-shale processing.

Sources of fuel and power in Brazil are reviewed, and analyses of oil shales from various localities are given. Mining practice is briefly described. C. A. F.

1307. Development of a successful multiple percussion drill carriage. H. J. Ballinger. *U.S. Bur. Mines Rep. Invest., No.* 4625, Jan. 1950.—The report outlines the development of a successful multiple drill carriage or "jumbo" which has been used in the U.S. Bureau of Mines experimental oil-shale mine near Rifle, Colorado.

Long-feed drills are mounted on a suitable jumbo, and detachable bits, which can be hard-surfaced with acetylene-tube borium, are used. The elimination of drill-rod changing saves much time and manpower.

The mechanical construction of the jumbo is described, and three figures are given. C. A. F.

Corrosion.

1308. Discussion on the corrosion of steel. Anon. *Paint Technol.*, Mar. 1950, **25** (171), 113.—At a joint meeting of the Iron and Steel Institute and the British Iron and Steel Research Association held in London on Oct. 18, 1949, the following papers were among those presented:—

A simple form of accelerated atmospheric corrosion test.
The effect of shot-preening upon the corrosion-fatigue of a high-carbon steel.
Corrosion-fatigue of steel under asymetric stress in seawater.
High-speed rotor tests of paints for under-water service.
Electrochemical studies of protective coating on metals.

A brief discussion of each of these papers is given. D. K.

1309. Adsorption of organic corrosion inhibitors on iron and steel surfaces. Electron diffraction studies. N. Hackerman and H. R. Schmidt. *J. Phys. & Colloid Chem.*, 1949, **53** (5), 629–38.—Adsorption of polar organic compounds on metal surfaces was detected by electron-diffraction methods. It was found that variations in structure between different materials is due primarily to the No. of adsorbed layers and to the orientation of the molecule on the metal surface. In several cases a finite rate of orientation was observed and measured. Firmness of adherence can be judged by a relatively simple procedure.

The application of the information obtained in this study to the inhibition of corrosion will appear elsewhere. The paper is well illustrated by photographs, and fourteen references are given. D. F. J.

1310. Corrosion. Soil bacteria affect metals and coatings. Anon. *Pipe Line News*, Jan. 1950, **22** (1), 30.—This is a review of a paper on "corrosion control on high pressure gas distribution systems."

It was found in an area where soils were relatively non-corrosive and the pipe was coated and cathodically protected, that there was a correlation between pipe corrosion and bacterial influence.

Microbiological analysis of soil samples indicated that members of at least three groups of sulphur bacteria, one iron and nitrate reducing bacteria were always present.

It is concluded that underground corrosion may be caused by any of several groups of bacteria where conditions favour their development and activity. C. G. W.

1311. Corrosion products on zinc anodes used underground. E. A. Anderson. *Corrosion*, 1950, **6** (4), 129.—When zinc anodes are used in the cathodic protection of pipelines, the presence of sulphates such as gypsum in the soil around these electrodes largely prevents the loss of current flow found after a time in ordinary soils. The mechanism by which sulphates affect the resistance of the corrosion-product film is investigated. The product adjacent to the zinc was a porous, needle- or plate-like mass of crystals of basic sulphate, and the outer layers were a dense, white mixture of the basic sulphate, and basic carbonate. The permeability of the basic zinc sulphate layer may account for its superior electrical conductivity. A hypothesis for the mechanism of formation of the two layers is given. J. T.

1312. The use of ammonia in control of vapour zone corrosion of storage tanks. F. T. Gardner, A. T. Clothier, and F. Corydell. *Corrosion*, 1950, **6** (2), 58.—Laboratory results have shown that ammonia in concentrations as low as 0·4% in systems containing 2% hydrogen sulphide by volume can effectively control vapour zone corrosion. Results of experimental field work carried out with 55,000-brl tanks have shown that the efficiency of protection gradually increased from 16% when an inhibitor injection rate of 1·4 lb/tank/day was used to almost complete protection when 12–15 lb/day were added to the tank vapour zone. The uninhibited corrosion rate measured simultaneously in tanks in similar service averaged 273 mg/sq. decimeter/day, for the entire test period.

In a typical installation the use of ammonia will result in a saving of over 88% of the cost of uncontrolled corrosion which compares favourably with the cost of other means of protection investigated. J. T.

1313. Neutralization as a means of controlling corrosion of refinery equipment. E. G. Camp and C. Phillips. *Corrosion*, 1950, **6** (2), 39.—Results obtained by using neutralizers as a means of controlling corrosion of refinery equipment are summarized. Methods used in injecting sodium hydroxide, ammonia, and lime are given. Detailed information is presented on the results obtained on the use of ammonia in controlling corrosion of equipment in connexion with distillation, cracking, gas absorption, debutanization, and steam systems. The injection of sodium hydroxide into cracking units and the use of sodium hydroxide and soaps in controlling corrosion of distillation equipment are discussed. J. T.

1314. Field and laboratory evaluation of petroleum-base rust preventatives. E. L. Walters and R. G. Larsen. *Corrosion*, 1950, **6** (3), 102.—A rough correlation exists between the field and laboratory types of measurements. The scope of the investigation carried out is extensive, and permits statistical interpretation of the influence of atmospherics, environment, composition, and application variables on the performance characteristics of both rust-preventative coatings and films. J. T.

1315. Field and laboratory tests of sodium chromates and alkalies for controlling corrosion in gas-condensate wells. C. K. Eilerts, R. V. Smith, F. G. Archer, L. M. Burman, F. Greene, and H. C. Hamontre. *Corrosion*, 1950, **6** (4), 131.—Investigations of the Bureau of Mines, begun in 1944, have shown that chromates are effective and economical inhibitors for controlling corrosion in gas-condensate wells. Low concentrations of the inhibitor in the water phase of the flowing fluid reduce the rate of corrosion in the flowstring to negligible values. The chromates are not equally serviceable in all wells and fields. The principal problem of their use is one of preventing their reduction to insoluble hydrous chromic oxide which may be deposited on the walls of the tubing and obstruct flow. Maintaining a high pH in the flowstream

by injection of alkalis with the chromates and avoiding high concentrations of the latter in the flowstream are effective in minimizing the reduction of the chromates by substances that occur in some reservoir fluids. Costs of chemical treatment in two gas-condensate fields have shown that corrosion protection by means of sodium chromates and alkalies adds less than one dollar to the expense of producing a million cu. ft. of gas. J. T.

1316. The performance of certain stoving paints and other painting schemes used to protect steel sheet against atmospheric corrosion. J. C. Hudson. *Paint Technol.*, Mar. 1950, **15** (171), 101.—A brief report is given of tests made on some protective schemes, embracing both stoving and air-drying paints, under ordinary conditions of outdoor exposure at normal atmospheric temperature. The protective schemes included two-coat systems of both stove and air-drying paints, the former included black enamels, black Japan, and 100% phenolic resin, and the latter zinc chromate and Burntisland, red lead followed by bituminous paints, and bituminous paints. Each painting scheme was applied to two pieces of mild-steel sheet measuring 6 in × 4 in × 16 S.W.G. The specimens were exposed outdoors at Selly Oak, Birmingham, for five years. Results of these tests are tabulated. The 100% phenolic resin and a red-lead protective scheme protected the basis steel effectively. Crazing of two of the bituminous paints used was observed at an early stage of exposure. The performance of black stoving enamel A was judged to be good in relation to its low weight of coating. Photographs are included. D. K.

Engines and Automotive Equipment.

1317. Increasing the thermal efficiencies of internal-combustion engines. J. M. Campbell, D. F. Caris, and L. L. Withrow. *S.A.E. Trans.*, Apr. 1949, **3**, 341–53.—The necessity for improved efficiencies in spark-ignition engines is stressed, and past work on the improvement of the engine–fuel relationship is outlined. The relationship between C.R. and fuel, air and fuel, design factors, part-load performance, and the interrelationship of several of these factors are discussed, as is also the connexion between road and laboratory octane ratings. Operating data are presented on the GM 12·5 to 1 C.R. engines, and possible developments therefrom are indicated.
J. G. H.

1318. Overcoming diesel knock. Anon. *Mech. World*, 31.3.50, **127** (3298), 353.—Research engineers at the Shell laboratories at Thornton have shown that diesel knock can largely be overcome. This is achieved by injecting into the cylinder a very small quantity of fuel, or " pilot charge," an appreciable period before the main fuel charge is due to be pumped in. The pilot charge becomes ignited and forms a torch which sets light to the main charge immediately the latter enters the cylinder. By this means there is at no point an accumulation of oil in the combustion space, and the burning of the fuel is smooth over the whole period of fuel injection. This system is known as the " pilot-injection " system. A. S.

1319. Doxford engine trials on heavy fuel. Anon. *Motor Ship*, Apr. 1950, **31** (363), 8.—These tests were carried out on a standard 3-cyl Doxford opposed piston engine, 600 mm bore and 2300 mm combined stroke, after the shop test on Pool diesel oil had been completed on January 12. The heavy fuel used was Shell-Mex with a visc of 3500 Redwood I at 100° F. Results are given of piston wear, fuel consumption, and exhaust conditions, together with details of fuel-oil characteristics and the centrifuge carried out on it. I. G. B.

1320. A new high-performance lightweight diesel engine. Anon. *Mech. World*, 24.3.50, **127** (3297), 313.—A new high-performance lightweight diesel engine has just been announced by the Rover Company. One feature in particular is its high power-to-wt ratio, and although it develops 320 b.h.p. at 2400 r.p.m. its dry weight is only 1500 lb. The engine is a four-stroke cycle, overhead-valve type, and has eight cylinders arranged in two banks of four, mutually inclined at 60°. Its bore and stroke

are 5·4 in and 6 in respectively and the C.R. is 16·5 to 1. Engine-design details are given in the paper, particular reference being given to a number of outstanding features which make the engine suitable for a wide range of industrial as well as automotive uses. A. S.

1321. Furnace safety. Anon. *Aircr. Prod.*, Apr. 1950, **12** (138), 122.—Details are given of a new flame-control fuel-supply system. The principle depends on the conductive properties of the flame, and the system consists of a heat-resisting steel probe which makes an electrical circuit via the flame to the burner, the small current being amplified to operate electrically the fuel-supply valve. I. G. B.

1322. The Shell–Ricardo lubricating-oil test engine. D. Downs. *J. Inst. Petrol.*, 1949, **35**, 748.—Design considerations and features of this test engine are described. A. R. W. B.

MISCELLANEOUS.

1323. Application of air-foam to oils burning in bulk. J. H. Burgoyne, L. L. Katan, and J. F. Richardson. *J. Inst. Petrol.*, 1949, **35**, 795.—*Part I.* The way in which the application of air-foam extinguishes burning oils has been studied. The mechanism is found to depend on the burning characteristics of the oil and on whether the foam is applied from above the burning surface or by base injection. With an adequate rate of top application to an oil having a surface temperature of not more than 100° C (benzole, motor spirit) a blanket of foam can form at once, and appears to extinguish the fire by interrupting the transfer of heat from the flames to the oil surface, hence preventing volatilization of the fuel. The extinguishing of heavier fuel and lubricating oils is also described.

Part II. The extinction of burning Pool fuel oil with top- and base-applied air foam has been studied quantitatively on a 40-gal scale, and some general conclusions are indicated. A. R. W. B.

1324. Use of solid carbon dioxide to extinguish the burning of liquids. J. H. Burgoyne, L. L. Katan, and J. F. Richardson. *J. Inst. Petrol.*, 1949, **35**, 818.—The utility of solid carbon dioxide as an extinguisher of fires involving liquids in bulk has been examined. The mode of action of CO_2 depends upon its state of division. Powdered material, and in some cases small lumps, floats on the burning liquid and cools the surface. In these circumstances the effectiveness of the application is, broadly, increased as the liquid-surface temp and extinction temp are greater. Larger grades of CO_2 sink in the inflammable liquid, and their evaporation causes an effect similar to air stirring. Liquids of high surface temp and those which form a hot zone are more effectively treated by this method than by the surface application of fine material. A. R. W. B.

1325. Some practical aspects of the problem of applying foam to large tanks. E. Thornton. *J. Inst. Petrol.*, 1949, **35**, 829.—Very large tanks require inordinate amounts of foam, and very much complicate the problem of overhead application. Larger and lighter pipes and limited points of entry seem worth consideration. Base injection is attractive on account of the lower quantity required and greater certainty of entry, the possibility of eliminating all extra pipe work becomes possible and practicable, as foam-making plant can work against higher back pressures. "Portables" should have means of elevating plain pourers only, foam being generated at ground level. Large-scale technical tests are necessary to test this attractive solution. A. R. W. B.

1326. Oil from shale—experience in the United States. R. A. Cattell. *J. Inst. Petrol.*, 1949, **35**, 841.—A highly mechanized system of underground quarrying has been developed to mine shale for 60 cents a ton. Research is developing fundamental information concerning the characteristics of oil shale and shale oil. Low-boiling shale-oil distillates have a hydrocarbon composition similar to cracked petroleum products, but include substances that are characteristic of coal tars. Hydrogenation will

improve these distillates so that they can be refined by conventional means to produce satisfactory substitutes for petroleum products.

Estimates indicate that shale oil can be produced with continuous retorts at costs below $2.00 a barrel. A. R. W. B.

1327. Synthetic liquid fuels. Annual report of the secretary of the interior for 1949. Part IV. Oil from secondary recovery and refining. *U.S. Bur. Mines Rep. Invest., No.* 4654, Feb. 1950.—An introduction summarizes research progress and commercial-plant cost estimates made, in 1949, under the entire synthetic liquid fuels programme.

This, Part IV, describes some physico-chemical studies of interfacial forces in relation to oil production, and records information on the following: engineering studies of secondary-recovery at five fields; engineering research on secondary-recovery problems at three field and experimental stations; techniques and laboratory analyses for secondary-recovery research; petroleum chemistry and refining related to sulphur compounds.

Ten illustrations and twelve literature references are given. W. H. C.

1328. Report of petroleum and natural-gas branch. Fiscal year 1949. R. A. Cattell and Others. *U.S. Bur. Mines Inf. Circ., No.* 7551, Feb. 1950.—A review is given of the progress in research, during 1949, of the Bureau of Mines and associated institutions and concerns mentioned. The review covers the various phases of work carried out under the following divisions: oil and gas development and production, secondary recovery; petroleum chemistry and refining; thermodynamics of petroleum; transportation of natural gas; helium production and process development; helium utilization and research.

Forty-five reports relative to the work are listed. Tabulated data and twenty illustrations are presented. W. H. C.

1329. The International Temperature Scale—1948 revision. J. A. Hall and C. R. Barber. *Brit. J. Appl. Phys.*, Apr. 1950, **1** (4), 81.—The 9th General Conference of Weights and Measures held in Paris in October 1948 adopted "The International Temperature Scale of 1948," being a revision of "The International Temperature Scale of 1927." The essential details of the new scale are given, and its novel features discussed.

The most important differences are: (1) the use of 960·8° instead of 960·5° C for the freezing point of silver; (2) the adoption of the Planck equation instead of that of Wien for extrapolation to high temperatures; (3) the use of a value of 1·438 instead of 1·432 for the constant C_2 in the Planck equation; (4) the use of the name "Celsius" instead of "Centigrade."

The effect of these changes on the numerical value of temperature is given in graphical form. The reproducibility of the scale is discussed, and an estimate is made of the accuracy with which it represents the thermodynamic scale. R. V. W.

1330. Survey of cycling plants. Anon. *Oil Gas J.*, 20.4.50, **48** (50), 233.—A summary is given of cycling plants in the U.S.A. showing their distribution and capacities. Operations are carried out in seven states by forty different companies. Total capacity is 7,251,800 gal of liquid daily. G. A. C.

1331. Survey of natural-gasoline plants. Anon. *Oil Gas J.*, 20.4.50, **48** (50), 223.—A summary of natural-gasoline plants in the U.S.A. is given, showing distribution and capacities.

464 field processing plants with a total of 22,362,650 gal daily for all liquids, produce gasoline, and liquefied petroleum gases from natural gas. G. A. C.

BOOKS RECEIVED.

1949 Book of A.S.T.M. Standards Including Tentatives. Part 1. Ferrous Metals. Philadelphia : The Society. Pp. xxvii + 1372.

Part 1 of the triennial publication of the A.S.T.M., which now appears in six parts. Material subdivisions include steel piping materials ; steel flat products ; steel bars, bolts, and rivets ; steel billets, forgings, and axles ; steel rails and accessories ; spring steel and steel springs ; concrete reinforcement ; corrosion tests for corrosion-resisting steels ; metallic-coated steel products ; welding electrodes and rods ; magnetic materials.

B.S. 1639 : 1950. Notes on the simple bend test. London : British Standards Institution, 1950. Pp. 15. 2*s.*, post free.

These notes are complementary to the bend test clauses of B.S. 485, and apply to methods of carrying out a simple bend test. They do not purport to indicate the actual severity of the test that should be imposed on any given specimen of material.

Bibliographie des Livres, Thèses et Conférences Relatifs a l'Industrie du Pétrole. Marthe Agout. Paris : Standard Français des Pétroles S.A., 1949. Pp. 322.

This bibliography of 6408 references to petroleum literature published during the period 1847–1947 is a valuable addition to the library. Although this volume was prepared to overcome the lack of a French bibliography dealing with the whole of the petroleum industry, it cannot fail to be of inestimable value to all who have need to use the literature.

The references are classified under about 400 headings similar to those used by DeGolyer and Vance and based on the decimal index of Prof. Uren. An author index and an alphabetical subject index are provided. For the benefit of French users, an indication is given as to the libraries in which the books may be found.

Le Pétrole, matière première pour l'industrie chimique. Paris : Association française des Techniciens du Pétrole, 1949. Pp. 482. 1200 francs.

The proceedings of the Association's Technical Oil Meeting which was held in Paris from June 20 to 25, 1949. Both French and English texts are given of the papers presented. Titles include : " Recovery of the French refining industry and its development in European economy," by Robert André ; " Economic intervention of the great sources of energy in the chemical industry," by M. E. Spaght ; " Technical and economic aspects of the place of petroleum derivatives in the chemical industry," by L. Jacqué ; " Solvents and plasticizers, properties of molecular structure," by H. Guinot ; " Solvents and plasticizers, industrial developments," by F. H. Braybrook ; " Production and purification of olefins and aromatics from petroleum as raw material," by H. Steiner ; " Properties and performance characteristics of synthetic rubbers, plastic and fibres from petroleum," by E. V. Murphree ; " Biological application of petroleum products," by G. H. Visser ; " Fluidized solids technique and its application," by E. V. Murphree ; " Structure and properties of surface active agents," by J. P. Sisley ; " Synthetic detergents," by H. E. Bramston-Cook ; " Scientific considerations on future development of petroleum chemistry," by G. Hugel.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER.

JUNE 1950.

The following have applied for admission or transfer to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidates.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Applications for Membership.

BAILLIE, William Gibson, mechanical engineer, Anglo-Iranian Oil Co. Ltd. (*H. Macniven ; W. H. Baker.*)

BONNAMI, Camille, director, Petrofina Ltd. (*G. Godeau.*)

BOWYER, Leonard James, assistant chemist, British Railways. (*D. J. Emery ; F. W. Bristow.*)

BULLOUGH, Stanley Hewlett, Captain, R.A.S.C. (*P. F. Ellis ; E. J. Horley.*)

CROWSLEY, Leslie Harry, engineer, United British Oilfields of Trinidad Ltd. (*F. A. D. Griffiths ; J. L. Andrews.*)

KEEVIL, Percy W., fuel manager, Ellesman Lines. (*H. F. Jones ; C. Chilvers.*)

MCLEOD, Alastair, managing editor, Industrial Newspapers Group. (*W. S. Ault ; P. Kerr.*)

RAW, William Stanley, driller, Trinidad Leaseholds Ltd. (*F. Hawes ; H. Gilmour.*)

SOUTER, Alexander Ley Gordon Fyfee, Captain, R.A.S.C. (*P. F. Ellis ; E. J. Horley.*)

VENN, Donald Charles Travers, junior production foreman, United British Oilfields of Trinidad Ltd. (*J. L. Andrews ; W. E. Madden.*)

WEBB, Geoffrey Thomas George, industrial lubricants engineer, Anglo-American Oil Co. Ltd. (*W. E. J. Broom ; E. W. Hardiman.*)

WOOD, Leonard Harry Percy, laboratory assistant, "Shell" Refining & Marketing Co. Ltd. (*N. E. Jones ; I. A. B. Pender.*)

Transfers.

ARNOLD, Ernest Hockley, factory manager, Burmah-Shell Installations. (*Associate Fellow to Fellow.*)

GEMMILL, John Smith, engineer records officer, Anglo-Iranian Oil Co. Ltd. (*H. Murphy ; E. J. Horley.*) (*Associate Member to Associate Fellow.*)

GODFREY, Richard, manager, Producing and Development Dept., Bahrein Petroleum Co. Ltd. (*S. L. Witard ; N. Matheson.*) (*Member to Fellow.*)

JENKINS, Edgar Harold, Flight Lieutenant, R.A.F. (*H. J. Moule ; L. H. Cooper.*) (*Associate Member to Associate Fellow.*)

KENDALL, Norman, research engineer, "Shell" Refining & Marketing Co. Ltd. (*C. D. Brewer ; A. J. Ham.*) (*Associate Fellow to Fellow.*)

LEE, George Herbert, group leader, Esso European Laboratories. (*A. Osborn ; H. L. West.*) (*Member to Fellow.*)

LONGBOTTOM, Frank William, chemical engineer, Manchester Oil Refinery Ltd. (*E. J. Dunstan ; J. Wood-Mallock.*) (*Associate Member to Associate Fellow.*)

MATTHEWS, Thomas Henry, chief chemist, Messrs. William Walker & Sons. (*E. Thornton ; R. H. Hall.*) (*Member to Fellow.*)

O'CONNOR, Desmond Dominic Taaffe, production engineer, Trinidad Petroleum Development Co. Ltd. (*J. S. Collcott ; C. Wilson.*)

PARSONS, Philip, plant operator, Anglo-Iranian Oil Co. Ltd. (*E. J. Horley ; P. F. Ellis.*) (*Student to Associate Member/Fellow.*)

STRADLING, Thomas Eric, process operator, Anglo-Iranian Oil Co. Ltd. (*P. F. Ellis ; E. J. Horley.*) (*Student to Associate Fellow.*)

NEW MEMBERS.

The following elections have been made by the Council in accordance with the By-Laws.

Elections are subject to confirmation in accordance with the By-Laws.

As Fellows.

GLOVER, T. B. THORNYCROFT, O.

Transferred from Associate Member to Fellow.

HIGGINS, G. O.

As Members.

BATHO, Sir M. B.
LE BROQUY, N.
SMITH, A. C.
SMITH, H. W.
WALEY, G. F.

Transferred from Associate Member to Member.

CARTER, D. H.

As Associate Fellows.

ASQUITH, E.
BORROWS, E. T.
DANIELS, M. Y.
ELSAWI, A. E. D.
GARDINER, L. H.
KELLY, W. H.
MAJUMDAR, A. N.
MARRIOTT, A. I. C.
MOINUDDIN, M.
PELMORE, J. R.
PETTY, D. S.
ROBINSON, J. H.
SANDERSON, R. F.
SAWHNEY, D. I. S.
SILL, S. A.
SIMPSON, G.

As Associate Members.

ADAMS, A. L.
ANDREWS, R. E.
DOYLE, T. M. J.
FARR, W.
HUMPHREYS, R. F.
JONES, J. E.
KEMP, J. N.
MAYNARD, A. H.
McLEOD, J. W.
SHRAGAH, S.
SMITH, H. H.
TROWBRIDGE, G. W. J.

As Student.

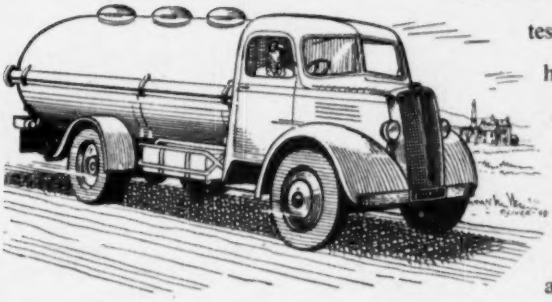
PIKE, D. A.

As Member Company.

MESSRS STEMCO LTD.

RUSTY ANSWER

Rustodian is a new answer to rust. This primer is based on a new lead compound and has been developed and tested over a number of years. Its tough film holds firm under all conditions and actively inhibits the formation of rust. Even when it is exposed to salt water or submerged under the sea Rustodian shows a remarkably strong resistance to blistering. The film, of course, may be broken or scarred, for accidents will happen, but Rustodian actively inhibits rust and protects bare iron *even after* the film has been scratched. Its life is as long as or even longer than Red Lead and under continual salt water test conditions Rustodian has shown a life of 90/112 days compared with a life of 10/14 days of other standard rust inhibitors tested. Rustodian is available in Light Stone and B.S.S. colours Light Brunswick Green, Dark Battleship Grey and Imperial Brown. We shall be pleased to send you full details if you write to



An ASSOCIATED LEAD PRODUCT

ASSOCIATED LEAD

MANUFACTURERS LIMITED

Ibex House, Minories, EC3 **London**

Crescent House **Newcastle**

Lead Works Lane **Chester**

in project engineering

the Lummus man

engaged in Project Engineering has a well diversified background of practical experience. Directly from a mechanical course at college, he entered the petroleum field and acquired his early experience with an oil company, either in the Engineering Department or in the Operating Department. He joined Lummus approximately 15 years ago, where his experience was extended covering all phases of engineering from laboratory, through design and planning to actual field construction. Concurrently keeping abreast of developments, he has maintained his standing as a licensed professional Engineer.

In his wide field of Project Engineering are included many of the world's outstanding refinery installations as well as petroleum chemical units.

The Lummus Project Engineer is "at home" with operations in foreign fields. He has a broad knowledge of the unique problems encountered in Europe, the Near East, India, the Orient, Latin America, and Canada, as well as those which confront him in the U.S.A. Project Construction in isolated locations present unusual difficulties in connection with problems of water supply, water disposal, housing facilities, personnel, etc., problems which the Lummus Engineer has handled successfully.

Your Project at Lummus will receive the attention of those Engineers whose experience will best fulfill your specific needs. Frequent requests by customers for reassignment of the same Engineers for "repeat" jobs is the best evidence of their competence.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

The Lummus Company, Ltd., 525 Oxford St., London, W.1, England
Société Française des Techniques Lummus 39 Rue Cambon, Paris, 1er, France
Compañía Anónima Venezolana Lummus–Edificio "Las Gradillas" Esquina Las Gradillas, Caracas, Venezuela

Kindly mention this Journal when communicating with Advertisers.

NOW, MORE EFFICIENT THAN EVER

The *BAKER* Model "K" Cement Retainer

●

For Greater Safety and Successful Results in . . . . .

RE-CEMENTING · SQUEEZE CEMENTING · CEMENTING BEHIND SECTIONS OF PIPE · TESTING UPPER CASED FORMATIONS · REDUCING GAS/OIL RATIOS · CEMENTING BAD PIPE · PLUGGING OFF BOTTOM FLUIDS · CEMENTING OFF TO PERFORATE FOR PRODUCTION · CEMENTING LOW-PRESSURE ZONES

For complete details refer to the BAKER (or Composite) CATALOGUE, or write direct to—

BAKER OIL TOOLS, INC.
Box 2274 Terminal Annex, Los Angeles 54, California, U.S.A.

equipped with a *BAKER* JUNK PUSHER

which pushes junk or debris down the hole ahead of the Retainer, and greatly minimizes the hazard of premature tripping of the Retainer by the fouling of the slips.

TWO EFFICIENT TYPES AVAILABLE

Baker Model "K" Cement Retainers are available made of Magnesium Alloy, which are readily drilled up by using drill pipe, tubing or cable tools, since all large parts are made of magnesium, except the nitricast-iron slips which are easily broken up. Magnesium Retainers have ample strength to withstand any pressure which can be imposed safely upon the casing or liner. Although Baker MAGNESIUM ALLOY Cement Retainers are satisfactory for *temporary* bridge plugs, they may be affected by well fluids, and CAST IRON Retainers are recommended for *permanent* bridge plug installations.

OPERATION OF THE BAKER JUNK PUSHER

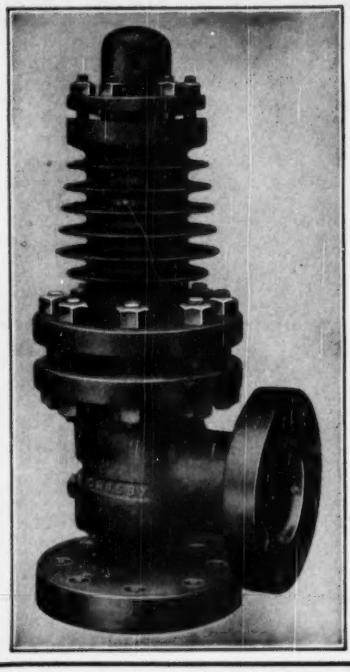
The Baker Junk Pusher (Product No. 403) has an outside diameter slightly smaller than the inside diameter of the casing in which the retainer is run. All debris tends to collect in the Junk Pusher. Slots permit passage of displaced fluid, but prevent passage of junk or debris which might foul the slips and result in premature tripping of the Retainer. The internal Screen, held in place by friction, prevents debris from entering the body of the Retainer, and is blown out at the proper time by the Tripping Ball Seat.

Keep your property in sound condition by regular repainting with MINERVA paint products. Wear, weather, rot and corrosion are always ready to attack unprotected surfaces... *to paint in time is a wise investment!* Minerva paint products combine efficient protection with attractive decoration, and they are used all over the world to keep buildings, bridges, vehicles and vessels in first-class condition.

PINCHIN, JOHNSON & CO. — EXPORT DIVISION

4 CARLTON GARDENS, LONDON, S.W.1 ENGLAND

TELEPHONE: TRAFALGAR 5400 CABLES: PULTRAMARJ, LONDON



CROSBY

RELIEF VALVES

FOR OIL REFINERY SERVICE

FOR ALL PRESSURES UP TO 2,700 LBS.
TEMPERATURES UP TO 1,000° F.

MASONEILAN
AUTOMATIC CONTROLS
FOR LEVEL, PRESSURE, ETC.

CROSBY VALVE & ENGINEERING CO. LTD.
251, EALING ROAD, WEMBLEY

STEIN
RAC
CEMENTS
ND PATCH
MAKSICCAR
MAKSICCAR
PATCH
MAKSICCAR II REFRACTORY CEMENT
This is air setting and gives a good bond at all furnace temperatures. It has high refractoriness (1690°C) and is remarkably constant in volume. By its use close tight joints are readily obtained.
MAKSICCAR PATCH
This is a superior, high refractory patching material for use in high temperature furnace construction and repair. Its softening point is 1750°C. For making quick repairs to burned-out brickwork, for filling odd corners in brickwork, or for making up on the site any special shape required, MAKSICCAR PATCH is eminently suitable.
JOHN G. STEIN & CO LTD. Bonnybridge · Scotland

Kindly mention this Journal when communicating with Advertisers.

PERSIAN GULF

An Oilwell Manifold erected by

MATTHEW HALL

& CO. LTD.

ESTABLISHED 1848

MATTHEW HALL

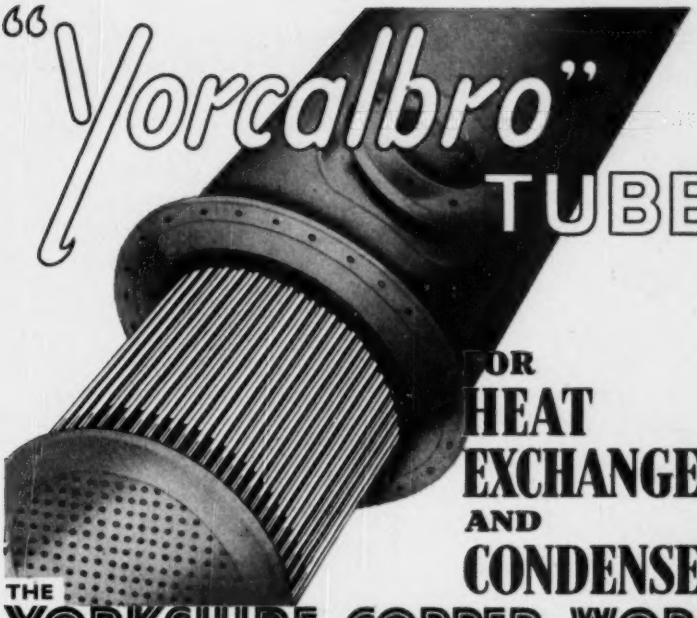
WELDED OIL PIPELINES
ERECTION OF PLANT AND MACHINERY
AIR CONDITIONING AND REFRIGERATION
HEATING AND ELECTRICITY

26–28 Dorset Square, London, N.W.1
Paddington 3488 (20 lines)

Glasgow Manchester Liverpool Belfast Bristol Newcastle Cardiff Coventry
EIRE MALTA GIBRALTAR AFRICA MIDDLE EAST

Kindly mention this Journal when communicating with Advertisers.

"Yorcalbro" TUBES



FOR
HEAT
EXCHANGERS
AND
CONDENSERS

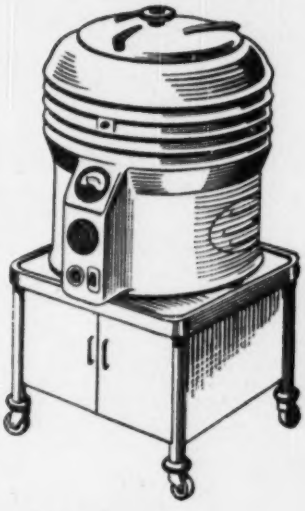
THE
YORKSHIRE COPPER WORKS
LIMITED
LEEDS

AND BARRHEAD, SCOTLAND

MSE
LONDON

"OIL-TESTING" CENTRIFUGE

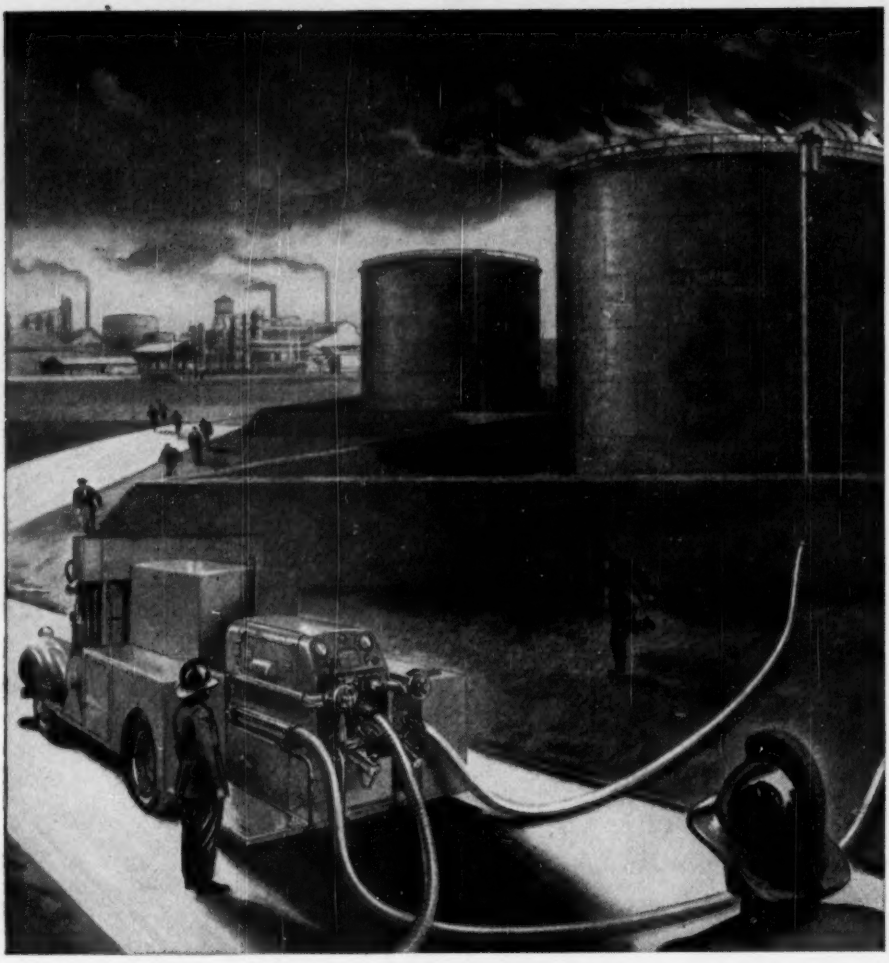
This new machine has been specially designed for carrying out all the standard centrifuging oil and petroleum tests of the I.P., A.S.T.M. and A.P.I., using one basic head, merely by changing the various accessories to suit the glassware peculiar to different tests.



Full details from the manufacturers:-

MEASURING & SCIENTIFIC EQUIPMENT LTD., 14-28 SPENSER STREET, LONDON, S.W.1

Kindly mention this Journal when communicating with Advertisers.



Modern—Scientific FIRE PROTECTION FOR OIL STORAGE TANKS

The highly specialised fire protection essential to the safety of bulk storage of oils and spirits is provided within the wide range of "PYRENE" Fire Fighting Equipment. The latest combination of fire appliances for the protection of new or existing tank installations is illustrated above. This comprises a "PYRENE" Mechanical Foam Tender operating in conjunction with fixed foam risers carried through the bund to a foam hose coupling. The tender carries 500 gallons of "PYRENE" Foam Compound, two "PYRENE" Mechanical Foam Generators and six 50-lb. cylinders of CO_2 gas with two CO_2 hose reels and gas distributor horns. It is equipped with an independent fire pump of 350/500 g.p.m. capacity. Water is obtained from either a hydrant or static supply. Its total output is 90,000 gallons of foam and 2,400 cubic ft. of CO_2 gas without replenishment. As an alternative to the above protection there are various forms of fixed "PYRENE" Foam Installations and Portable Telescopic Foam Towers. Full details and specifications will be forwarded on request.

Pyrene TRADE MARK FIRE PROTECTION

THE PYRENE COMPANY LIMITED, DEPT. J.I.P. 9 GROSVENOR GARDENS, LONDON, S.W.1

TEL. VICTORIA 3401

Kindly mention this Journal when communicating with Advertisers.

Two-way flow

IT is a great advantage to have reversible-flow pumping equipment on a Road Tank as the one shown above has. Intake and delivery then become independent of outside help.

Most liquids can be successfully transported in bulk by road . . . According to the loads, Butterfields build Road Tanks in stainless steel, mid steel, or aluminium. When necessary, means of insulation are provided.

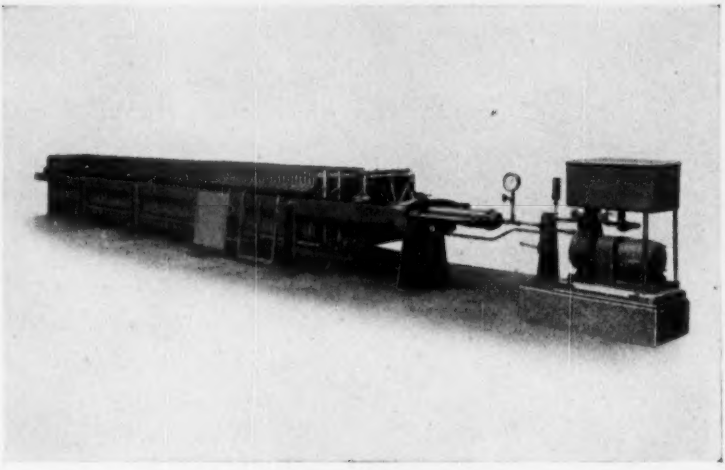
Butterfield Road Tanks are able to do their work in an economical, efficient way because they are specially built for their specific job.

Do you know? From the chassis stage, Butterfields can do the rest. Building the tank, provision of ancillary equipment, painting and writing in first-class style, ready for the road.

BUTTERFIELD ROAD TANKS

W. P. BUTTERFIELD LTD., SHIPLEY, Yorks. *Tel. 52244 (7 lines)* **AFRICA HOUSE, KINGSWAY, LONDON, W.C.2.** *Tel. HOL 1449*

WAX MOULDING PRESSES



The above press has 100 moulds giving a cake 24" × 12" × 1½".
Fitted with hydraulic closing gear.

OUR wide and long experience in the manufacture of wax moulding presses makes us specially suited to meet the most varied demands. May we submit proposals to suit your requirements?

A. F. CRAIG & CO. LTD.

CALEDONIA ENGINEERING WORKS

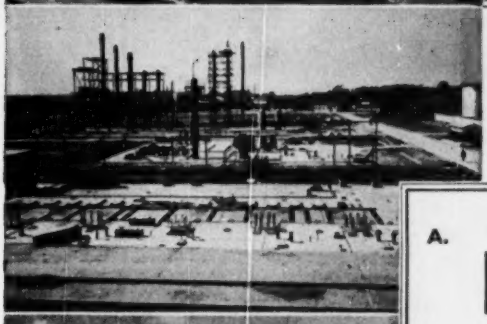
PAISLEY • SCOTLAND

London Office: 727 Salisbury House, London, E.C.2

Telephone: MONarch 4756

American Associates:

THE KOCH ENGINEERING COMPANY, INC., WICHITA, KANSAS



New Shell Chemical Plant, Stanlow, where the civil engineering and most of the building was carried out by our organisation. Further contracts are at present being executed for Shell on other projects.

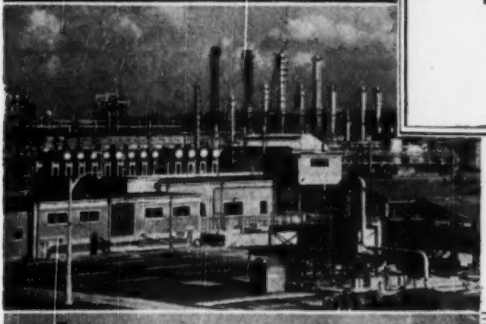
Shell Photographs

A.

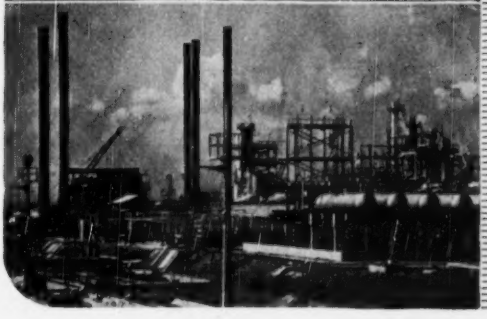
MONK

& CO LTD.

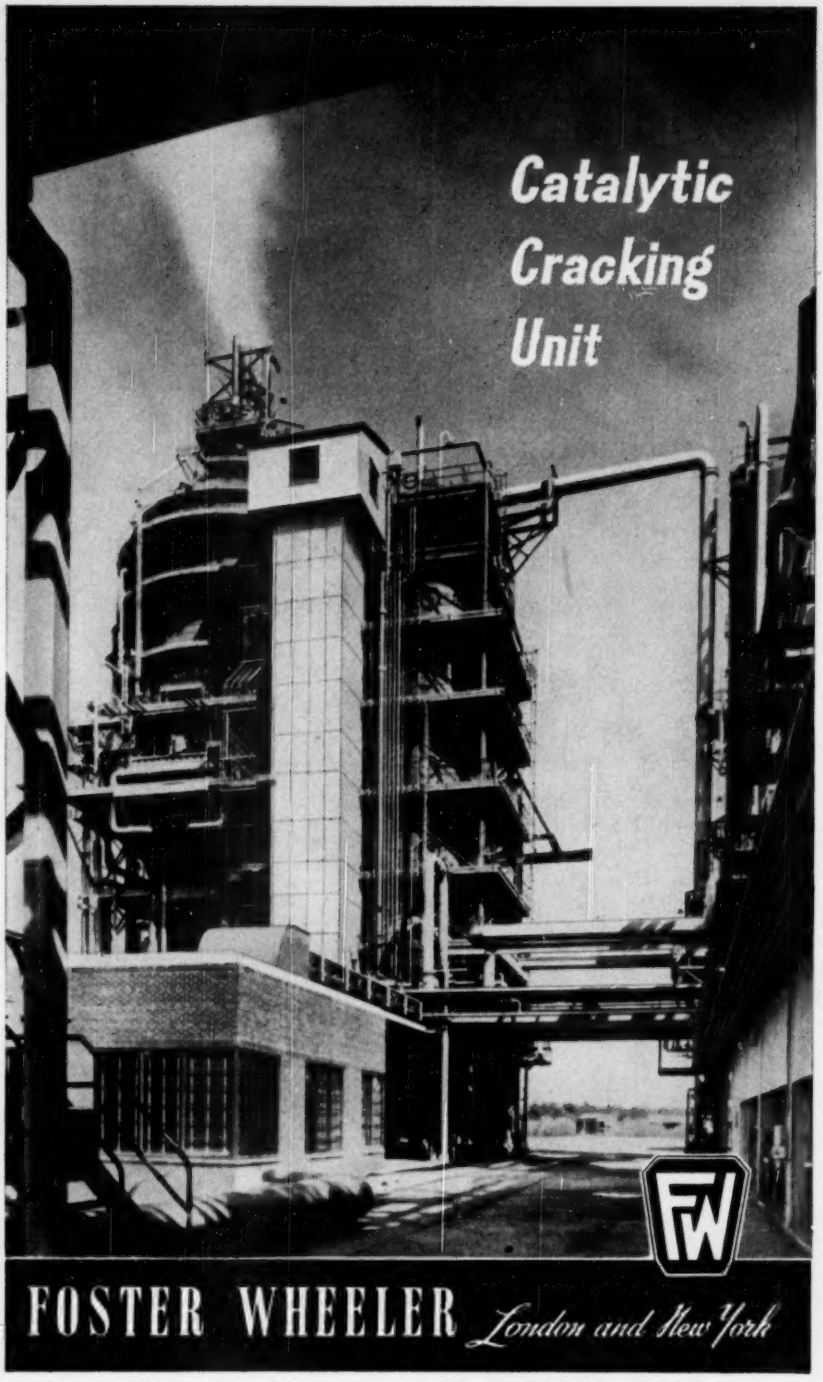
CONTRACTORS
PADGATE
WARRINGTON



We are fully organised and equipped to undertake all civil engineering and building work in connection with Oil Chemical Plants, Oil Refineries, Harbour Works and Pipelines, etc., and have already completed contracts to the value of many million pounds at home and overseas.



117·52


Catalytic
Cracking
Unit
FW
FOSTER WHEELER London and New York

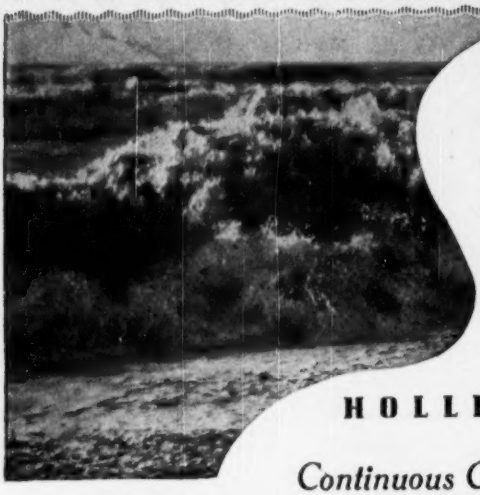
WEIR

AUXILIARIES for the OIL INDUSTRY

Steam, Diesel or Motor-Driven Pumps, Reciprocal and Centrifugal types, for all refinery duties; Heat Exchangers; Air Compressors; and all power plant auxiliaries for Boiler Feeding and Feed Heating. Write for Catalogue Section IE.8 "Weir Pumps for the Oil Industry".

G. & J. WEIR LTD., CATHCART, GLASGOW, S.4

CONTINUOUS WASHING



Holley Mott Plants are efficiently and continuously washing millions of gallons of Petroleum products daily. Designed for any capacity. May we submit schemes to suit your needs?

HOLLEY (H M) MOTT

Continuous Counter-Current Plant

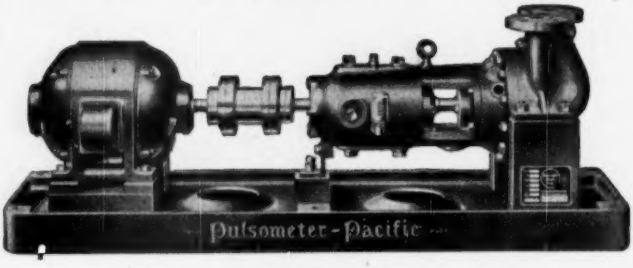
Telegrams:
"Typhagitor, Fen, London."
Telephone: Royal 7371/2.

World-Wide Licensees, **H.M. CONTINUOUS PLANT LTD.**
FOUR LLOYDS AVENUE, LONDON, E.C.3.

Pulsometer-Pacific

Trade Mark

OIL REFINERY PUMPS



S.V.C. Single-Stage Type. List No. 3258

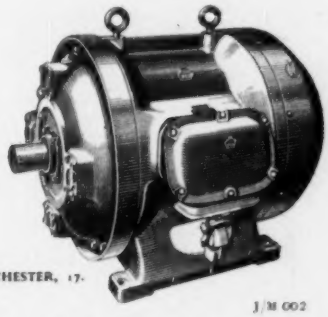
Pulsometer Engineering Co. Ltd. Reading

ENGLAND **Established 1875**

IN THE OIL WORLD THEY SAY ...

"That's good, it's an M-V Motor"

Oil wells and refineries throughout the world rely on M-V electrical equipment. 'Metrovick' experience of motors and their proper application covers all drives in the oil industry, from drilling to refining. Site engineers well know how M-V electrical equipment brings their complex plant into active life.



250 h.p. Type FS Motor.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PARK, MANCHESTER, 17.

J/M 002

METROVICK *Motors for all Industrial Drives*

Represented in :

VENEZUELA, TRINIDAD AND CURACAO—Neal and Massy Engineering Co. Ltd., Port of Spain, Trinidad, B.W.I.

IRAN—Kooros Brothers, Teheran.

SAUDI ARABIA—Saudi Electric Supply Company, Mecca, P.O. Box No. 94.

ARGENTINA—M.V.E. Export Co. Ltd., Avenida Pte. R. Saenz Pena 636, Buenos Aires.

IRAQ—Dwyer & Co. (Iraq) Ltd., Airlines House, King Faisal Ave, Baghdad.

INDIA—Associated Electrical Industries (India) Ltd., Crown House, 6, Mission Row, Calcutta 1.

Kindly mention this Journal when communicating with Advertisers.

DRILLING MUD:
ITS MANUFACTURE AND TESTING

By

P. EVANS, B.A., F.G.S., M.Inst.Pet.

and

A. REID, M.A., B.Sc., M.Inst.Pet.

Reprinted from Transactions of the Mining and Geological Institute of India, Vol. 32 (1936)

pp. 263 + xxx. Paper covers

Price 21s. post free

Obtainable from

THE INSTITUTE OF PETROLEUM

26 Portland Place, London, W.1

Introducing 2 new Lincoln Electrodes

'POSITIONWELD'

for fast

easy flow

low spatter

ARC-WELDING

'MULTIWELD'

These are Lincoln's new easy-flow Shield-Arc electrodes—economical yet with no compromise in the famous Lincoln quality. Multiweld is the answer to insistent trade demands for a first-class all position electrode with speed and easy handling, good penetration and a high-quality deposit. Positionweld has all the same advantages but is even easier for vertical and overhead use. These two are a perfect example of the Lincoln service to industry.

World's largest manufacturers of arc-welding equipment and electrodes

LINCOLN

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920

S.M.6

Kindly mention this Journal when communicating with Advertisers.

and if Insulation 2" thick
Heat = 20·5 . . . p.a.
KENYON
Economic Thickness = 2½"
Planned
HEAT INSULATION
= 800 π / (1/(2×0·053) log_e 20·75/12·75 + 1/0·15 log_e 21·75/20·75 + 12/18×21·75)
= 483 BTU's/linear ft/hr
Efficiency of Insulation = Bare Pipe loss − Insulated loss / Bare Pipe loss × 100
= 12,700 − 483 / 12,700
∴ η = 96·4%

Before recommending thermal insulation for any class of equipment—process plant, steam generation plant or insulating bulk transport vehicles for liquids at high temperature, Kenyon undertakes a complete survey, and make thorough calculations to arrive at the scheme which represents the best balance between capital expenditure and thermal efficiency.

WM. KENYON & SONS LIMITED · DUKINFIELD · CHESHIRE

KH80

Kindly mention this Journal when communicating with Advertisers.

Glitsch

TRUSS-TYPE

BUBBLE TRAYS

The Glitsch "Truss-type" design has extreme flexibility and carries out your processing requirements economically. Other advantages include time saved in erection, cleaning, maintenance and inspection.

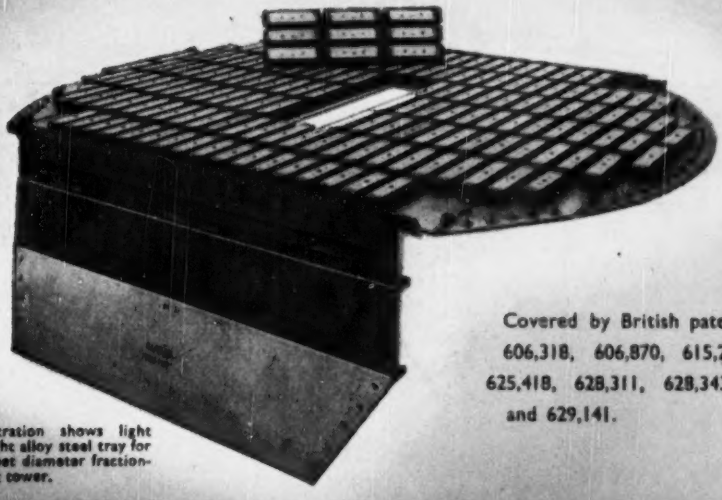


Illustration shows light weight alloy steel tray for 12 feet diameter fractionating tower.

Covered by British patents 606,318, 606,870, 615,228, 625,418, 628,311, 628,343 and 629,141.

CM6

MADE IN GREAT BRITAIN BY

METAL PROPELLERS LTD.

74 PURLEY WAY, CROYDON, SURREY.

TELEPHONE: THORNTON HEATH 1404 (4 LINES) TELEGRAMS: METAPROPS, SOUPHONE, LONDON

ACCURATE INDICATION
DEPENDABLE PERFORMANCE

Klinger

LIQUID LEVEL GAUGES

FOR REFINERIES AND STILLS

Richard Klinger Ltd., are specialists in the manufacture of direct reading liquid level indicators for the Oil Industry, and make a wide range of types to meet the varying conditions of service.

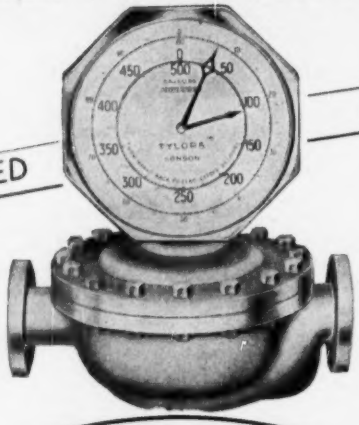
RICHARD KLINGER LTD.
KLINGERIT WORKS · SIDCUP
KENT · TEL: FOOTSCRAY 3022

"K" Type Reflex Gauges for oil pressures up to 1,200 lbs. per square inch and steam pressures up to 500 lbs. per square inch. They are available in a full range as single or combined units and have forged steel bodies with stainless steel tightening nuts and end tubes. Reflex gauges are also made for higher pressures up to 6,000 lbs. per square inch.

"J" Type Double Plate or Thru-Vision gauges for working pressures up to 500 lbs. per square inch are recommended where coloured or opaque liquids have to be indicated. Heavier pattern Double Plate gauges are available for pressures up to 2,000 lbs. per square inch.

VOLUMETERS FOR OIL, PETROL AND OTHER PETROLEUM PRODUCTS

MAINTAINED ACCURACY



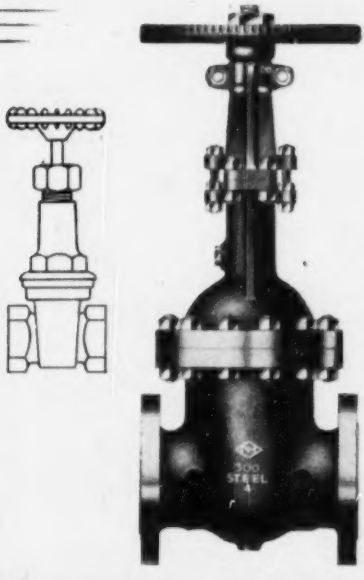
BALANCED PERFORMANCE RUGGED CONSTRUCTION

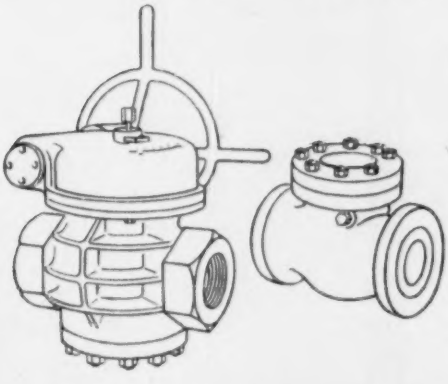
APPROVED BY THE BOARD OF TRADE (Standards Department)

TYLORS LIMITED
BELLE ISLE
ESTABLISHED 1777 **LONDON, N.7** 'PHONE: NORTH 1625

Valves and fittings

Designed & Developed for Oilfield Efficiency





Our range of specialised productions for the Oil Industry includes CAST and FORGED STEEL, CAST IRON and BRONZE Gate, stop and Check Valves for all pressures and temperatures, for water, steam, oil, air and gas services.

Newman, Hender & Co. Ltd

WOODCHESTER GLOS. ENGLAND.

PHOSPHORUS DERIVATIVES

ENQUIRIES ARE WELCOMED FROM OIL ENGINEERS FOR:

Phosphoric Acid
Trisodium Phosphate
Tripotassium Phosphate
Acid Sodium Pyrophosphate
Tetrasodium Pyrophosphate
Sodium Metaphosphate (Calgon)
and
Phosphate Glass (62·7% P_2O_5)

ALSO FOR CARBON TETRACHLORIDE

Manufactured by

ALBRIGHT & WILSON LTD

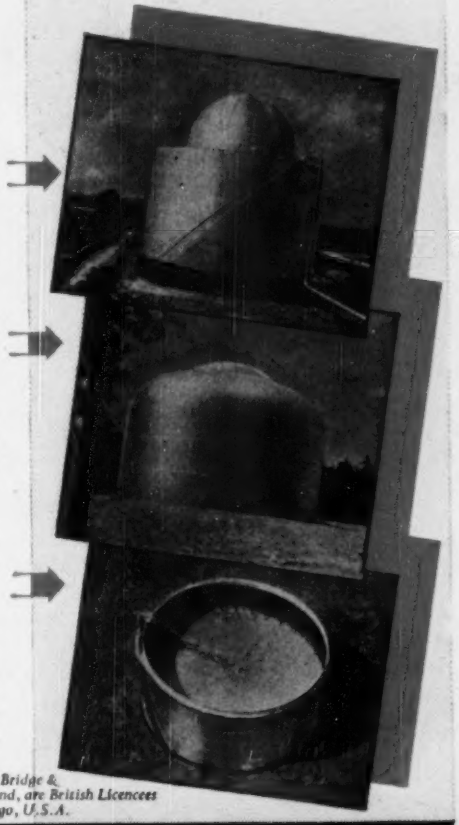
49 PARK LANE · LONDON · W·1 · *GRO* 1311

Works: OLDBURY & WIDNES

TSW 210

WHESSOE *provides these methods for reducing evaporation—*

- VAPOUR STORAGE SYSTEMS
  In association with the *Chicago Bridge and Iron Co. Vapordome Roof tanks, Vaporspheres, Horton Lifter Roof tanks. *(Illustration shows tank 60 ft. dia. x 40 ft. high, with 38 ft. dia. Vapordome.)*
- PRESSURE STORAGE SYSTEMS
  Hemispheroids, Hortonspheroids, Spheres, Pressure Roof tanks. *(Illustration shows 20,000 bbl. capacity Hemispheroid 2½lbs. per sq. in. pressure.)*
- VAPOUR SPACE ELIMINATION
  Horton Double-Deck Floating Roofs, Horton Pontoon Floating Roofs, Horton Pan Floating Roofs, fitted with latest type Pantagraph Hanger for butt-welded tanks. *(Illustration shows tank 80 ft. dia. x 40 ft. high with Horton Double-Deck floating Roof.)*
- TANK FITTINGS
  Whessoe Limited make and supply S. & J. tank fittings under licence from Shand & Jurs Co., Berkeley, California, U.S.A. P. & V. valves and special pressure-tight gauging devices are available—particulars on application.



*Whessoe Limited, jointly with Motherwell Bridge & Engineering Co., Ltd., Motherwell, Scotland, are British Licencees from the Chicago Bridge & Iron Co. Chicago, U.S.A.

WHESSOE LIMITED DARLINGTON

LONDON - 25 VICTORIA ST. S.W.1

Telephone: Abbey 3881 Telephone: Darlington 5315

Kindly mention this Journal when communicating with Advertisers.

EDECO
ROCK BITS
FOR SPEED & STRAIGHT HOLE
The EDECO ROCK BIT is manufactured by English Steel Corporation Limited in conjunction with the English Drilling Equipment Co. Ltd. The EDECO ROCK BIT has been designed, engineered, built and tested by a team of American experts who have specialised in building Rock Bits. English Steel Corporation have the facilities for making any known high grade steel, and the S.A.E. Steel used in the EDECO ROCK BIT is identical with that used by the American Rock Bit makers.
All the processes from the selection of the materials through all the stages of forging, machining, welding and heat treatment are carried through inside the English Steel Corporation Plant. There is, therefore, full assurance that the EDECO ROCK BIT is made of the finest materials and under the supervision of experts at every stage.
TRINIDAD OFFICE:
P.O. BOX 27, SAN FERNANDO,
TRINIDAD, B.W.I.
TELEPHONE: SAN FERNANDO 819
ENGLISH DRILLING EQUIPMENT Co LTD
BILBAO HOUSE, 36/38, NEW BROAD STREET, LONDON, E.C.2
TELEPHONES: LONDON WALL 1991 & 1992
TELEGRAMS: BULLWHEEL, AVE, LONDON

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

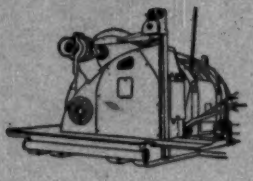
G. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

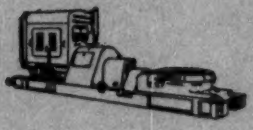
Kindly mention this Journal when communicating with Advertisers.

EVERYTHING YOU NEED FOR DRILLING FROM ONE RELIABLE SOURCE "OILWELL"

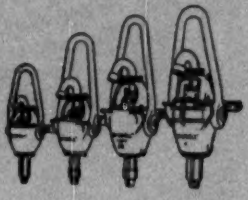
YOU get fast, economical drilling with the "Oilwell" line of drilling equipment. All the major rig components, including draw works, rotary drilling unit, swivel, pump and blocks, are the result of "OILWELL'S" long experience in the design and production of reliable oil-field machinery.



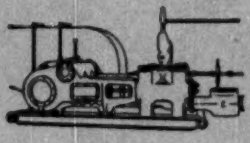
THE "OILWELL" NO. 96 RIG for deep drilling, and the "OILWELL" NO. 64-B RIG for medium depths, are outstanding in their class. A perfected and centralized system of air controls permits the speedy operation from the driller's position of all clutches and speed selections.



"OILWELL" ROTARY DRILLING UNITS are noted for their smooth operation and flexibility. They are available with two forward and one reverse gears. All "OILWELL" ROTARIES have the same general construction, and differ only in size and capacity.



"OILWELL" SWIVELS, recognized for their advanced design, have been used on many of the world's deepest wells. Four sizes, ranging from 100 to 400 tons capacity, provide a choice for any drilling requirement.



"OILWELL" PUMPS include a wide range of models suitable for every oil-field application. From the huge No. 220-P Power Slush Pump to the small No. 6P-HD for general service use, they embody construction features based upon time-proved design.

Whether you need a complete drilling rig or only a single item remember "OILWELL" is a good place to buy all your oil-field equipment and supplies.

OIL WELL SUPPLY COMPANY

Incorporated in U.S.A. with Limited Liability

5 QUEEN STREET, LONDON, E.C.4

With Representatives to Serve All Oil Fields

UNITED STATES STEEL

"OILWELL"